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JAN 19 1923 Received

Vol. 46,
No. 544

# The Marine Engineer

## AND NAVAL ARCHITECT.

Editorial and Publishing Office—
33, Tothill Street, London, S.W. 1.

JANUARY, 1923.

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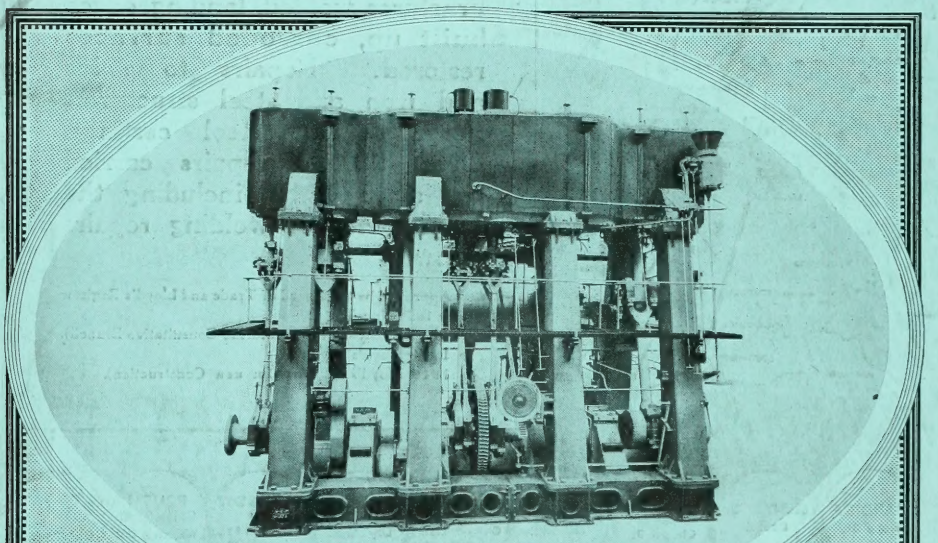

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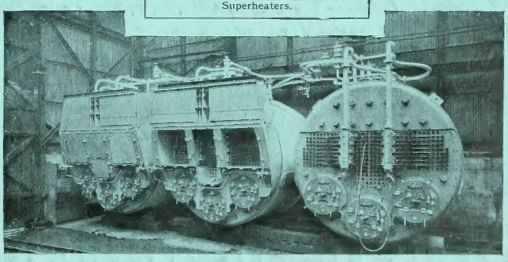

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# The Marine Engineer
## AND NAVAL ARCHITECT.

*A Practical Journal for all Concerned in the Design Construction and Maintenance of*

MECHANICALLY PROPELLED SHIPS — MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES — WELDING & MECHANICAL REPAIRS
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PUBLISHED EVERY MONTH
AT
33, TOTHILL STREET, WESTMINSTER, LONDON, S.W.1.

Telegraphic Address: TECMARINE, Vic., London.
Telephone: VICTORIA 8836.

Annual Subscription payable in advance and postage free:

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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

VOL. XLVI. No. 544. JANUARY, 1923.


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*An Index to the Forty-Fifth Volume of* THE MARINE ENGINEER AND NAVAL ARCHITECT, *covering the issues January–December*, 1922, *is presented as a Supplement to each copy of this month's issue.*

Mr. John T. Rouse, Superintendent-Engineer of Coast Lines Limited, who died in June last, at the age of 62 years, has left estate of the gross value of £2,808.

The late Alderman Robert Readhead, J.P., of Westoe, South Shields, of the firm of John Readhead & Sons Limited, West Docks, South Shields, left estate of the gross value of £707,124, with net personalty £685,230.

Mr. F. J. Miners, who until recently represented Clover, Clayton & Co., in Liverpool, has commenced business on his own account, and will represent, in Liverpool, Elliot & Jeffrey, ship-repairers, engineers, &c., of Cardiff and Barry Docks.

Hick, Hargreaves & Co., Soho Iron Works, Bolton, have recently appointed Mr. Percy N. Everett, Assoc. M.Inst.C.E., as Manager of their Oil Engine Department. Mr Everett was, until his appointment, Chief Diesel Engineer with Sir W. G. Armstrong, Whitworth & Co. Limited, Elswick.

Captain William Marshall, D.S.O., has been placed in command of the White Star liner *Celtic*, and made his first passage in the vessel as commanding officer recently. He served his apprenticeship in "sail," and has since commanded the White Star liners *Teutonic*, *Megantic*, *Arabic* and *Cedric*.

The Board of Directors of the Union-Castle Line have appointed Mr. E. F. Abbott to be one of the Joint Managers in succession to Mr. H. J. Gandar, who has retired on account of ill-health. For the last three years he has been Assistant Manager of the Line; Mr. James McNaught has been appointed as his successor.

Captain J. P. Cuming, late Marine Superintendent of the Larne and Stranraer steamers, was recently presented by the officers and crews of the steamers with a handsome escritoire on the occasion of his retiring after twenty-five years' service. Captain Cuming commanded the first turbine steamer placed on the Irish passenger service.

The death took place recently of Mr. B. S. Broadhurst. He was Managing Director of the Brush Electrical Engineering Company, and had been with this Company in various capacities for over forty years. He had been in failing health for some months, but his death was ultimately due to internal trouble, which was such as to render an operation impossible.

Captain John Roberts, C.B.E., D.S.O., has been appointed Commander of the White Star liner *Baltic*; his last ship was the *Celtic*; the appointment of Captain William Marshall, D.S.O., we have mentioned above. Captain Roberts, like his successor on the *Celtic*, served his apprenticeship in "sail," and has been in the White Star employ for over a quarter of a century.

The death has recently taken place of a well-known marine salvage expert—Captain John Ellis. He joined the Liverpool Salvage Association, as Master of the salvage vessel *Hymna*, about twenty-five years ago, and commanded other vessels of the Association since then. He assisted in the raising of sunken vessels at the entrance of Belgian ports, and returned to Liverpool late last year.

We regret to announce the death, which took place recently, in Glasgow, of Colonel John McAusland Denny, C.B., D.L. Colonel Denny was born at Dumbarton in 1858, and received his early education at the local Academy, afterwards studying at Lausanne, in Switzerland. At the age of 17, he entered on a special course of training for the commercial side of shipbuilding, and started work in the counting-house of the firm, later obtaining the necessary practical experience. Later, he rose to the control of his branch of the large business, and made frequent journeys abroad in the interests of the firm. Denny Bros. did a large business for many years in building vessels for the Russian Volunteer Fleet and for the Russian Government of the pre-Bolshevik era. For British owners the firm have constructed many notable vessels, including the *King Edward*, the first commercial turbine steamer, a vessel which is still successfully plying on the Clyde. In this work Colonel Denny took a keen personal interest, as he did in all the lines of scientific research carried out by his firm. From the time he became a partner in the firm, he took an active part in its management, and in 1919 he was appointed Chairman of the Company in succession to his cousin, Mr. James Denny. He was elected Member of Parliament in 1895 for the Kilmarnock District of Burghs, and continued to represent this constituency until 1905, when he was obliged to withdraw from the then approaching Election on account of his health. He was a Justice of the Peace and a Deputy-Lieutenant for Dumbartonshire, and was connected with a number of business concerns. Colonel Denny, is succeeded in the Chairmanship of the Company by Mr. Maurice E. Denny, and Mr. John M. Denny becomes Vice-Chairman.

# EDITORIAL.

## "THE BATTLE OF THE TALENTS."

IN the early days of marine engineering, lookers-on were privileged to witness a great battle of wits—a pitting of opinion and experience one against the other—we refer, of course, to the "Battle of the Boilers." In those days, as at the present time, lookers-on saw most of the game. At the present day the looker-on can witness just such another battle—psychological rather than concrete, as an undercurrent rather than as a visible "rapid." We refer to the absence of liaison between two great branches of industry—the men who think scientifically, and the men who think, and act, commercially. The scientist is essentially the fundamental producer, and the commercial man is without a doubt the man who applies these fundamental products and turns them into channels which will benefit the community in general and, as he devoutly hopes, himself in particular. There is a distinct tendency for each group to hold the other at arm's length and although each is absolutely and entirely necessary to the other, yet there is no reasonable co-ordination between the two.

The following extract from the review of an engineering paper, read before one of our leading technical societies, appeared recently in one of our contemporaries, and is interesting in that it reminds us forcibly of this ever-existing breach between the technical man and the practical man, and of the rather dubious attitude from which the latter sometimes regards the former. The passage we have in view reads as follows:—"Whether the audience were able to appreciate, or even to follow, the mathematical calculations involved is a moot point. The formidable-looking algebraical formulæ are sufficient in themselves to frighten most practical engineers who have probably forgotten most of the higher mathematics they learnt as students . . ." This statement certainly causes one furiously to think and to wonder why it should even be necessary at all; nor, in passing, do we quite agree with the qualifying term "algebraic" in describing the formulæ used, since any formula is by reason of its fundamental derivation algebraic. Mathematics and mathematical investigations are sometimes regarded by practical men with distrust and even with suspicion, whereas the only true and fair way of considering such a science is to regard it as a shorthand for expressing conveniently some known and proven physical laws. In common fairness, we must admit that the mathematician rather delights in smothering himself, as it were, in symbols which are not always of the simplest character—we refer, for instance, to the use of esoteric symbols—but, other things being equal, it will be found generally, that the end justifies the means. The gap between the man of action and the man of theory is an ever-present one, and, as we have suggested, is widened by suspicion and distrust. This is unjust, unwise and unnecessary, since one side cannot exist successfully without the assistance of the other, and each, for efficient production, must work in conjunction with the other. We would suggest that the fault lies on both sides and that it can only be remedied by a better mutual appreciation. The practical man should realise that, to quote but one example, without the theorems and deductions involved in Euler's Theory of Struts, he would not be able to support his decks and longitudinal girders; that without the vast amount of preliminary research work carried out in connection with internal-combustion engines the motorships of the present day would be an impossibility. On the other hand, the theorist should not condemn a paper read before any scientific society as valueless or even as of mediocre value, simply because it is written for practical men by a practical man who is placing on record of his best—his actual experience; what he has done, and what can be done, especially in view of the fact that, from an entirely unbiased standpoint, it is usually accepted that, in a good many cases, theory has to be modified slightly in order to conform with the rigorous and inelastic laws of practice. What then, it may be suggested, is the solution to the problem? Certainly there can be no definite victory for one side or for the other. The solution must be essentially a compromise in which will be expressed by each group its definite appreciation and acknowledgment of the value and necessity of the other.

## THE PRODUCTION OF MECHANICAL GEARING.

DESPITE the fact that some form of speed-reduction gearing is recognised as being absolutely essential on all vessels propelled by steam turbines, we are far from having heard the last word as to what constitutes the most suitable form of speed-reduction gearing to employ. Of the three systems of speed-reduction that have been advocated, viz., the mechanical, the electrical and the hydraulic, the mechanical is the only one which has been adopted to any large extent, and, with the exception of the application of the electrical speed-reduction system to some of the recent war vessels of the United States Navy, it may be said that the electrical and the hydraulic speed-reduction systems have hardly emerged from the experimental stage. This leaves us then with mechanical gearing as the only well-tried system which is available for giving the necessary reduction of speed between the turbine and the propeller. But, as recent papers before the various shipbuilding and marine engineering institutions have shown, mechanical gearing still leaves something to be desired, and shipowners are not yet convinced that in the steam turbine, fitted with mechanical-reduction gearing, they have the most reliable and economical form of marine steam engine that can be devised.

In the early days of the geared turbine, when a single-reduction gear could be employed to give the necessary ratio between the speed of the turbine and that of the propeller, it was found that the gears were well able to render the service demanded of them, although cases of failure with single-reduction gears are not unknown. But with the development of the steam turbine, when, in order to obtain the highest economy of steam consumption, very high speeds of rotation were employed, it became necessary to employ double-reduction gearing in which the necessary reduction of speed between the turbine and the propeller shaft was obtained in two steps. These gears have not proved nearly as satisfactory in service as the single-reduction gears, and very many instances of failure have to be recorded. These failures have tended to create a feeling of doubt as to the suitability of the double-reduction gearing for marine propulsion, and many investigations have been undertaken with a view to determining the causes which may be held responsible for the failures and, if possible, to effect a cure. As a result we find that numerous theories have been advanced by different investigators to account for the peculiar behaviour of the gears they have examined, but all these are weakened by the fact that similar double-reduction gears are in successful operation. Thus we are almost compelled to conclude that the causes of trouble lie not in the design but in the construction of the gear, and that it is inaccuracy in the cutting of the teeth which more than anything else sets up the disturbances which ultimately lead to failure.

In order to ensure that the teeth of the different wheels and pinions which constitute a set of gears shall be produced with the maximum degree of accuracy, various systems of tooth-cutting have been devised, the advocates of each of these systems claiming that by their particular method perfectly accurate tooth forms can be obtained. Of these different systems the best known is probably the hobbing system which was perfected by Sir Charles Parsons, and which has been very extensively adopted for cutting all kinds of double-helical

gearing. The chief disadvantage of this system lies in the fact that the hobbing machine upon which the wheels are cut ceases to yield accurate results when the machine shows signs of wear, or even when the hobs themselves have become worn. Another system which has been extensively employed for the cutting of marine gears is the Sykes gear-generating system, in which the cutters in the form of helical pinions are given a combined reciprocating and rotating motion, which causes them to generate the correct tooth form on the wheel blank. The form of the teeth on the cutters is purely involute, and they are ground back in such a way that throughout their entire life they generate exactly the same form of tooth when cutting. In the Sunderland process use is made of the fact that the form of the involute tooth for a rack is composed entirely of straight lines. The cutter therefore takes the form of a rack, and the teeth are slotted as the wheel rolls along the rack. Here the chief advantage lies in the fact that a straight-sided cutter is employed which can be very accurately ground to form after hardening. It may be noted that many competent judges have declared that this is the system which yields the most accurate form of wheel.

All the systems noted above are used in the production of a double-helical form of tooth. Mention must, however, be made of the Maag gear, in which an ordinary straight tooth form is adopted. This system has not yet been tried for the transmission of large powers, but for normal sizes it appears to possess certain marked advantages over the double helical form of tooth. In the Maag gear the pinion wheel is hardened after cutting the teeth, and the teeth are then ground accurately to form by a special grinding machine in which plane disc grinding wheels are employed. This ensures almost perfect accuracy as well as a high degree of polish on the pinion.

## HORSE-POWER MEASUREMENT.

THE introduction of new types of engines for the propelling of ships has led also to the introduction of many interesting ways of measuring the horse-power developed by these engines. In the days when the reciprocating steam engine was the only form of engine used for the propulsion of ships, the measurement of the horse-power developed demanded only the taking of indicator diagrams from each cylinder, a task of such simplicity that it could easily be carried out when the ship was on trial, and, when the vessel was in actual service, left to one of the junior engineers. The determination of the horse-power from the diagrams was likewise a fairly simple matter, and it became almost a matter of routine to calculate the indicated horse-power of the main engines once during each voyage, and in this way not only was it possible to determine whether the performance of the engines was other than it should be, but the shape of the diagrams often gave an indication of the source of the trouble, particularly if that trouble was caused by the side valves. The introduction of the steam turbine and the internal-combustion engine has to a very large extent ended this satisfactory state of affairs, for it is a matter of considerable difficulty to determine with any degree of accuracy the horse-power developed by either of these forms of propelling machinery, and hence the engineers on the vessel have little or no idea as to whether the engines under their care are performing with the same efficiency as they did during the acceptance trials.

Particularly in the case of the steam turbine, the measurement of the horse-power is a matter of considerable difficulty. So far no direct method has been devised which gives an indication of the power generated in a steam turbine, and we have been compelled to rely upon the indirect method of determining the angle of twist for a given length of the shaft, this furnishing a measure of the power being transmitted through the shaft. Numerous forms of torsion meters have been devised for measuring the shaft horse-power, and on turbine-driven vessels during the acceptance trial it is usual to fit one of these, thus giving the engineers some idea of the power developed by the engines under trial conditions. The torsion meter is, however, a rather delicate and complicated piece of apparatus which, while it can be easily used by skilled men such as are usually sent by the engine builders on the trial trips, would be found by the ship's engineers rather difficult to handle. The result is that torsion meters are not often carried as part of the equipment of the engine room, with the result that measurements of horse-power are seldom made on turbine-driven vessels, when once they have left the builders' hands. This is a matter for regret, because the conditions under which a turbine works, while not subject to the same amount of variation as are the conditions governing the performance of a reciprocating engine, yet they do vary to a certain extent with variations in the clearances, &c., and a frequent and periodical measurement of the power developed by the turbines might lead to the detection of these changes, and hence to the elimination of the defects which cause them almost as soon as they occur. The result would be a far greater economy in running and greater reliability of the turbines, due to the correction of defects as soon as they occur. Further, it is not unlikely that any defect which was beginning to develop in the speed-reduction gearing would also be detected almost from its inception if a periodical measurement of the shaft horse-power of the turbines was made, the power showing a gradual falling-off, despite the fact that conditions in the turbine are found to be unaltered.

The reciprocating oil engine does not at first sight appear to differ to any great extent from the reciprocating steam engine, from the point of view of the measurement of the power it develops. Indicator diagrams can be taken from the Diesel engine in exactly the same way as they can from the triple-expansion engine, and the diagrams, while they enable the indicated horse-power to be directly determined also serve to show whether the various valves are functioning correctly. The difficulty with the Diesel engine lies in the fact that, owing to the high temperature occurring in the cylinder, the indicator must be of special design, and of the best possible construction, if it is to be capable of working for any length of time without introducing certain severe errors, due to the variation of the tension of the spring as the temperature of the instrument rises, and also because of the increased vibration usually found in internal-combustion engines. The external spring indicator has to a large extent overcome the first difficulty, while exceptionally light construction tends to reduce the second. But the fact remains that the taking of indicator diagrams from Diesel engines is not regarded in the same light as is the taking of diagrams from steam reciprocating engines. Thus, while they are taken when the Diesel engine is on trial in the shops and during the acceptance trials, in many instances when the vessel is in service they are not taken, with the result that the engineers have no direct evidence that the engines are not performing in the same way as they did during the trial trips. This is greatly to be regretted, because, with the internal-combustion engine there is always a possibility that some small change may occur in the timing of the fuel valves or of the admission, scavenging and exhaust, and even a very small change in one of these materially affects the running of the engine. It is highly desirable with all classes of propelling machinery that, as far as possible, frequent measurements should be made of the horse-power developed, so that a check can be obtained on any gradual changes in the performance of the engines.

CONVERTED WARSHIPS.—The coast defence ships *Odin* and *Aegir* were converted to motor ships by the Wilhelmshaven yard about 18 months ago for the Reederei Arnold Bernstein, Hamburg. These vessels have proved so satisfactory that the same owners have placed an order with the yard for the similar conversion of the sister ship *Frithjof*.

# BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

**Brief Reviews of Recent Publications.**

**Elementary Internal-Combustion Engines.** By J. W. Kershaw, M.Sc., M.Eng. London: Longmans, Green & Co., 39, Paternoster Row, E.C.4. 5 in. × 7½ in. × ½ in. 207 pages. Price 5s. net.

This little work is now in its second edition, and we strongly recommend it to those who require a general knowledge of internal-combustion engines without entering into the matter from a more theoretical standpoint. Additions have been made to this edition, notably to the chapter dealing with oil-engines, and a collection of questions and answers, which has been added to the Appendix, will be found useful: the student of marine engineering will find a chapter devoted to oil-engines for ships. We feel that the title of the book is somewhat misleading, and we suggest that "Internal-Combustion Engines from an Elementary Standpoint" would be more fitting.

**Marine Works.** By Ernest Latham, M.Inst.C.E. London: Crosby Lockwood & Son, Ludgate Hill, E.C.4. 5½ in. × 8½ in. × ¾ in. 174 + xii pp. Numerous illustrations. Price 16s. net.

In this work the author deals in the opening chapter with the nature and effect of waves, and shows, in succeeding chapters, the influence of such waves on the construction, maintenance and repair of quays, berths and other marine works. Notable examples of damaged piers, quays, breakwaters, &c., are described and illustrated, and the question of the development of hydro-electric power from tidal sources is discussed. Having regard to the desirability of preserving the navigational facilities of our rivers and estuaries, the erection of tidal power barrages in many cases constitutes a serious obstacle to the development of hydro-electric schemes of this nature, and, generally, the author believes that their scope is likely to be somewhat limited. The book is prefaced by Mr. C. Le Maistre, C.B.E., Secretary of the British Engineering Standards Association.

**Elementary Seamanship.** By Captain Sir D. Wilson-Barker. London: Charles Griffen & Co. Limited, Exeter Street, Strand, W.C.2. 7½ in. × 5 in. × 1 in. 280 pp. Numerous drawings and illustrations. Price 7s. 6d. net.

The fact that this, the revised ninth edition, has been called for is ample proof that the book has been much appreciated by those men now at sea, and also that the call of the sea is still strong among British youths. As the author was captain of the *Worcester* for so many years his position has given him that knowledge as to which points are elementary and which are not.

The book opens with an elementary description of the construction of a vessel and proceeds to deal with ropes, knotting, splicing and handling, gear and tackles, rigging, sails and sailmaking, sailing, signalling, auxiliary machinery, wireless telegraphy, rules of the road and miscellaneous general information. This book is of a class that is always interesting, and the author has dealt with his subject in such a manner as to make the book both interesting and instructive to the reader, however young.

**The Internal-Combustion Engine.** (Fourth edition.) By H. E. Wimperis, M.A., F.R.A.S., M.I.E.E. London: Constable & Co. Limited. 5½ in. × 8½ in. × ¾ in. 320 + xvi pp. Numerous illustrations. Price 12s. 6d.

This work, which has now reached its fourth edition, requires no introduction to students of the subject. In arrangement the book is divided into three main sections, viz., Theory, Gas Engines and Gas Producers, Oil and Petrol Engines, from which it will be gathered that the scope of the work is wide. Each chapter is followed by an excellent series of examples to which the solutions are given at the end of the book. Marine engines and the marine Diesel engine, in view of the developments which are in progress, might have received greater mention—this branch of the subject is dismissed in some half-dozen pages. Reference is made to the gas turbine and the view is expressed that progress up to the present time does not warrant this prime mover being considered as a competitor with the internal-combustion piston engine. The author's treatment of the thermodynamics and associated theory of the subject is particularly good, and as a text book for engineering students this work is altogether admirable.

**Die Unterseeboote der Germaniawerft.** By Dr. Ing. her H. Techel. Berlin: Julius Springer, Bankstrasse 23-24, W.9. 9¾ in. × 12¼ in. × ¼ in. 103 pp. Numerous plates, sketches and diagrams. Price in Great Britain, 5s.

The student of German who happens also to be an engineer, and more especially a submarine engineer, can be certain of his money's worth if he invests in a copy of this book. We cannot admire many characteristics of our late enemies, and not even the healing passage of time will wipe out the contempt with which the whole world regards their unrestricted "U" boat warfare. As engineers, however, we cannot but give them credit for the vast amount of applied scientific knowledge which was worked into their submarine construction. As authors and publishers of technical works we cannot but feel that the Germans excel in such productions, which they can publish cheaply and in an attractive manner. This work is no exception to the rule. It deals clearly and lucidly with submarine design and construction from all points of view—stability, diving, navigational appliances, torpedos, mines, and an excellent section on submarine engines. Some general particulars of "U" boat types complete this at once comprehensive, useful, and interesting book. Where the author has found it either inconvenient or impossible to obtain photographs, he makes use of a technical artist and produces some excellent, technically correct little sketches—another point which some of our own publishers would do well to note. It is, we imagine, a book which will eventually find itself on the shelf of every engineer and naval architect interested in this subject.

## TRADE PUBLICATIONS.

*Electrical Equipment for Ships.*—A recent useful publication of the General Electric Company Limited, Magnet House, Kingsway, W.C.2, takes the form of a catalogue and is issued in loose-leaf pocket form for the convenience of engineers and others who in the course of their duty, and when away from their office, have constant need to refer to catalogues for particulars and prices of their requirements. The loose-leaf principle has been adopted so that the list can be constantly brought up to date by means of supplementary sheets which will be issued from time to time as need arises.

*SKF Ball and Roller Bearings.*—An abridged catalogue, published as a pocket edition, has recently been issued by the Skefko Ball Bearing Company Limited, of Luton. The catalogue, which appears in a detachable outer cover, besides containing some notes on lubrication, has also several tables of useful data in connection with the bearings.

# DIESEL MACHINERY AND ITS AUXILIARIES.

**Single or Twin Screw Considerations—Alternative Methods of Driving Auxiliary Machinery—Utilisation of Waste Heat in Exhaust Gases.**

The arrangement of Diesel machinery, as in the case of steam plant, is one which varies very considerably in accordance with the standards adopted by the shipbuilders, and is largely influenced by the idiosyncrasies of the superintendent engineer, who often has well-defined ideas as to his own requirements based upon actual experience with steam machinery, and while this is in itself not conclusive evidence of its suitability with a Diesel installation, it must be admitted to be very helpful.

The position of the engine room is, of course, fixed by well-defined rules, the tankers, for example, with their large cargo tanks affording ample provision for ballast, being fitted with the engines right aft to afford protection against the possibility of fire. For small coasting cargo vessels, where the accommodation is limited and where very little light running is anticipated, the same procedure is followed. In practically all other classes of vessel the machinery is arranged amidships.

## Single or Twin Screw.

In view of the limitations under which Diesel engine designers have laboured, the question of single or twin-screw machinery is one which has up to the present largely depended upon the Diesel engine builder. The Diesel engine has, with its comparatively high-speed units fitted to twin screws, undoubtedly suffered thereby in competition with the slow-running long-stroke steam engine, but the advent of the new long-stroke Diesel engine, which includes the opposed-piston designs, brings the Diesel engine in as a formidable rival to the single-screw steam engine. The problem of converting single-screw steamers to Diesel machinery has been much simplified by this new step, which obviates all the difficulties and troubles to be expected in arranging for twin screws to accommodate the older fast-running Diesel. The shipowner is now appreciating the advantages to be gained by converting to Diesel machinery, as evidenced by the numerous inquiries for this class of work, and doubtless it only requires a revival of demand for shipping to ensure activities in this direction to be rapidly extended.

Dealing with the choice of single or twin machinery for Diesel-engined vessels, the following are points which call for consideration in coming to a decision :—

(1) While it is claimed that slow-running units up to 4,000 i.h.p. in one screw are practicable, it would scarcely be desirable in the present state of the art to go up to this power, and the maximum which would be advocated on a single-screw slow-running engine would be in the neighbourhood of about 3,000 i.h.p.

(2) The single engine entails a longer engine room and, consequently, reduction in space available for cargo, assuming the same dimensions of the vessel.

(3) The cost of construction of a single unit with its attendant auxiliaries will be less than that for a twin arrangement, principally on account of the saving of the second line of shafting, although for the same cargo-carrying capacity the length of the single-screw ship would require to be increased to compensate for the extra length of engine room.

(4) The weight of each installation is approximately the same.

(5) The propeller efficiencies, regarding which much controversy exists, present such small differences, accepting the theories of advocates of either system, that they are almost negligible for practical purposes.

(6) The risk of total stoppage is less in the twin-screw arrangement than in the single screw, where a breakdown of the engine involves a stoppage of the ship, although it is now conceded that the Diesel engine is no less reliable than its steam predecessor.

(7) The cost of upkeep will be smaller in the single-screw machinery, while the personnel is smaller for the same aggregate power.

## Auxiliary Machinery.

Apart from the usual auxiliaries fitted as part of the ship's equipment, the Diesel engine brings in its train its own auxiliaries, *i.e.*, the cylinder cooling pump and the lubricating oil pump. According to the type of engine fitted, additional auxiliaries in the way of piston-cooling pumps, air compressors for storage reservoirs and for blast injection, and scavenging pumps, the last named for two-cycle engines only, are arranged.

The usual practice in the case of auxiliaries required for the main engine is, for small installations, to drive them from the engine itself, but for larger installations opinions vary considerably. The design of the usual marine type of oil engine restricts to some degree the accessibility obtained with the reciprocating steam engine, and while it is possible to offer a fairly open construction of oil engine, this is feasible only if the designer is not hampered by the necessity of making provision for appendages in the way of pumps, &c., which would also appreciably reduce the power available at the propeller shaft. Additional advantages in the adoption of separate auxiliaries offer themselves in the facilities for priming and running the various systems before starting and after stopping the engine, which is a desirable procedure from many points of view, and the ability to flush all bearings with clean oil in case of lengthy stoppages in port needs no emphasis as to its value. The engine-driven pumps are invariably of the constant volume type, and offer a disadvantage in so far as it is not practicable to adjust them conveniently to suit the requirements of the engine under the various conditions which might be expected on service.

The practice of fitting separately-driven auxiliaries is now being largely followed by the best makers, except, of course, where the demands of the shipowner or his superintendent engineer is contrary to what is considered to be good practice, but two outstanding instances, showing the extent to which this is being carried out, are exemplified by the m.s. *Domala* and the m.s. *Handicap*. In the first vessel, which is fitted with engines of the North British Diesel Company's design, the injection air compressors, of which two are fitted, are separately driven by Diesel engines. The duplication of injection compressors is a somewhat unusual condition for marine practice, where the compressor is usually driven by the main engines, the breakdown of the compressor involving the stoppage of the machinery or running the two engines at reduced output on one compressor. The power required by these compressors is noteworthy, *i.e.*, 400 b.h.p. each, representing nearly 10 per cent. of the total propelling power fitted in the vessel. With regard to the *Handicap*, a Sulzer-engined ship, the scavenging pump is of the turbo-blower type. The high speed of 3,000 r.p.m. at which this blower is run effects considerable economy in space. The power required in this case is in the neighbourhood of 6 per cent.

of the shaft horse-power of the machinery. The usual method of driving both these auxiliaries is from the engine direct, but since the efficiency of the independent system has been proved on service, it will undoubtedly be accepted to some extent in later practice, and the additional shaft horse-power set free from the main engine used either to fit into larger vessels or to increase the speed of existing types.

The method of driving the main engine auxiliaries, unless driven from the main engine itself, is very largely governed by the method adopted for driving the remaining ship's auxiliaries, which is determined to meet the particular requirements of the service as interpreted by the owner, who is guided to some extent by the builder and his recommendations for the machinery adopted.

### Oil Tanker Practice.

In oil tankers the universal practice is to fit steam auxiliaries, this policy being decided by the necessity for fitting boilers of large size for the steaming of the oil tanks. The provision of electrical auxiliaries in these circumstances would involve a considerable capital expenditure without any appreciable increase in the efficiency of the machinery as a whole. As, however, in certain sea conditions a very small power only is required, and an electric generator must of necessity be provided for lighting and for wireless work, this is on occasion increased somewhat in size to allow for the driving electrically of the engine auxiliaries only, the generator being driven by an oil engine. A steam-driven generator is usually provided for stand-by purposes and for use when the boilers are in operation for any other service. Apart from this class of vessel, the coming proposition is undoubtedly the driving of all auxiliaries either by independent oil engines, in the case of large-powered units, or electrically for pumps, compressors, &c.

### Electrically-driven Auxiliaries.

While it must be admitted that the capital expenditure is somewhat higher when all-electric auxiliaries are fitted, the marked fuel economy in operation is more than sufficient, in normal circumstances, to compensate, while, in addition, the saving in space of the electrically-driven machine lends itself to a much more compact and convenient engine room arrangement. Pump makers are not slow to observe the trend of progress, one maker specialising in a new type of vertical circulating pump arranged with the motor on top, which possesses an additional advantage in keeping the motor well clear of the floor-plates, with their usual accumulation of grease and dirt. This same type of pump, the upper portion of which is enclosed in a bell-shaped case, is also marketed for emergency bilge duties, and is capable of operation when entirely submerged, the motor being cooled by a fan which circulates the imprisoned air against the cool walls of the bell. A small air extraction pump is provided as an essential part of the equipment, which takes care of all air leakages in the main pipe line and ensures continuous operation of the main pump under all conditions.

In dealing with an all-electric auxiliary proposition, the provision of electric power on board ship presents features which are somewhat out of the line of the Diesel designer, in so far as the requirements of the vessel in the way of deck machinery and of such auxiliaries as the refrigerating plant and large pumping sets, as in oil tankers, which are usually handled by shipbuilders, are to be taken into consideration in deciding the power required. Upon this, to some extent, is dependent the type and number of generating units to be fitted. It is well known that no prime mover will operate economically and satisfactorily for long periods at powers much lower than their normal rating, and as in certain conditions of service comparatively low power is required, it is essential that the whole of the conditions shall be closely examined to put forward the best arrangement. Taking as a basis a good-class cargo passenger vessel, the varying requirements which will usually be met with would be as detailed below, the powers being adjusted to meet the actual known conditions when designing :—

| At sea. | Entering or leaving port. | In port. |
|---|---|---|
| Engine lubricating oil pump. | As at sea, with the addition of windlass, warping winch and starting air compressor. | Sanitary pump. |
| Engine cooling pumps. | | Bilge pump. |
| Air injection compressor. | | General service pump. |
| Scavenge pump (two-cycle). | | Winches. |
| Bilge pump. | | Engine turning gear. |
| Sanitary pump. | | Lighting, &c. |
| General service pump. | | |
| Steering gear. | | |
| Refrigerator. | | |
| Wireless. | | |
| Lighting, &c. | | |

The fresh-water pump, fuel-transfer pump and workshop motor would also be operated occasionally in the first two conditions, and the last named in port also, so that these should be taken into account when deciding the power and number of the generators.

It is desirable that, where two or more generating units are fitted, these should be of the same size and design to reduce the spares carried, in addition to which an added advantage is the better opportunity afforded for making one good unit.

Alternative methods of driving the dynamos offer themselves in the pure Diesel and the semi-Diesel engines, each of which has its own particular claims for recognition. If economy in operation is the primary factor, the Diesel engine is much ahead of its rival. Special care should be taken that this type of engine is worked up to nearly full load to obtain the maximum efficiency, and with this object in view it is usual to fit two, three or four engines of the same power, one engine acting as stand-by for emergency conditions. As against this, the semi-Diesel engine, although subject to the same limitation as regards efficiency at low ratings, affords considerable saving in capital cost, which to some extent compensates for the higher fuel and lubricating oil consumptions. The engine itself is very simple, and there are fewer parts to get out of order, thus lending itself to running by comparatively unskilled labour. The same type of fuel as used for the main engines can be utilised, and, with the latest types of semi-Diesel engines, starting can be effected in the matter of minutes.

### Engine Auxiliary Systems.

Notwithstanding the extensive experience which designers have had, no uniformity of opinion has yet been reached with regard to engine cooling, although on account of the additional complications both in gear and in weight the cooling of the jackets by fresh water is gradually being discarded, and it is only a question of a short time before sea water will be universally used. The difficulties to be overcome in the use of sea water for this purpose are mainly in connection with silting up of water passages when operating in muddy or sandy waters ; and the deposition of salt on the walls. In the case of piston cooling, however, the problem is more complex. The sea water advocates often arrange for a portion of the output of the jacket-cooling water pump to be increased in pressure in a special pump for piston cooling, care being taken to ensure perfect watertightness of all joints inside the crankcase, the deleterious effect of salt water on lubricating oil being well known to engineers, while the deposition of any mud and salt in the piston itself would affect the efficiency of the engine and would be very difficult to remove. With fresh water the problem is not so difficult from this point of view, since the action of fresh water on the lubricating oil is not so detrimental as is sea water, although of course this is not desirable.

The necessity for a closed system, however, and the fitting of a large cooler, which usually carries with it a separate circulating sea-water pump of large capacity, adds to the mechanical

complication and cost, while the weight of the additional gear, together with the fresh water and its tanks, is by no means small.

The fresh-water tanks are usually built as a part of the ship's structure. The water is drawn from the fresh-water tanks by a pump and passed through a cooler before passing through the pistons, the discharge being led back to the storage tanks, taking advantage as far as practicable of the natural cooling facilities due to the disposition of the tank.

The fitting of oil cooling gear is the easiest method available, particularly when conveyed through sway beams. Although advantageous from the point of view that difficulty due to leakage is not experienced so long as sufficient pressure is maintained to lift the oil to the top of the piston, the question of coolers is one of some concern, as these will require to be some three times or thereabouts the size required for the corresponding fresh-water cooling system, the disadvantages detailed for the fresh-water system applying with even more force with this system, which is the one usually adopted in the fast-running continental types of engines.

### Lubricating System.

The forced lubrication system adopted in oil engines is somewhat more complicated than in the reciprocating steam job, although to turbine engineers the system generally will be more or less familiar. In addition to the usual storage tanks carrying sufficient oil for any round trip, to enable this to be bought in the cheapest market, arrangements are made for drain tanks and settling tanks. The storage and settling tanks are usually fitted high up in the ship, while the sump is placed under the engine bedplate. The lubrication of the engine is of primary importance, and it is therefore essential that the pumps should be of a type to ensure that it will pick up under any condition of service. For this reason pumps of the plunger type, or positively acting rotary pumps, similar to the Feuerheerd, are invariably adopted. The importance of cleanliness in this system cannot be too forcibly emphasised, and strainers of large straining area are fitted on both the suction and discharge sides of the pump, both strainers being of the double type, so that they can be readily changed over for frequent cleaning. In addition, the oil from the sump is periodically pumped into the settling tank to separate the water and foreign matter. Further cleansing of the oil is often carried out mechanically by means of a pump sucking from the sump and passing it through a purifier of the de Laval or other type, the purified oil being returned to the sump after treatment. The lubricating pump is arranged to draw the oil from the sump, which is fed by gravity from the settling or storage tanks, and, after passing through the engine bearings, is returned to the sump. Where high temperature conditions are anticipated, oil coolers are usually fitted in the system on the discharge side of the pump, the cooling water for this system being taken from the discharge of the engine circulating water pump. An alternative method of operation is to arrange for the pump to deliver the oil from the sump to a special overhead tank arranged to give a head equivalent to a pressure of about 6 lb. or 7 lb. per square inch. This system, however, offers no particular advantage, and as no opportunities are available for varying the pressure to suit abnormal conditions, does not appear likely to supersede the arrangement most generally adopted.

A stand-by lubricating oil pump is generally fitted to meet the requirements of Lloyd's Register. This, in addition to stand-by services, is also used for pumping up the oil from the sump to the settling tanks.

### Fuel Oil System.

Great controversies have arisen regarding the ability of oil engines to use low-grade fuels, and while it is generally conceded that these can be consumed, the trend of expert opinion seems to indicate that the truest economy is to utilise in oil engines only those fuels which have been specially prepared for their use. Shipowners, however, are somewhat difficult to convert to this view, and designers are faced with the necessity of meeting their views in this direction. The cruder oils are usually of a very viscous nature and require heating to enable them to be handled by the pumps and passed through the pipes. Such oils could not be allowed to remain in the engine system when the engine is stopped as difficulty would be experienced in starting. This, therefore, renders it necessary for a secondary source of supply of lighter oil to be available, this being used in the engine for some hours before stopping to ensure that the system is free from crude oil.

The main storage tanks are arranged in the double bottoms, of a capacity, as in the lubricating system, sufficient for a round trip. A daily-use tank is fitted in a position sufficiently high for gravity feed to the fuel pump on the engine and is charged periodically by the fuel transfer pump. Strainers are fitted in the system between the daily-use tank and the engine pump.

### Air Starting System.

The stipulation called for in Lloyd's Rules, that sufficient air shall be stored to start the engine at least 12 times, seems to err in the direction of being somewhat short to meet ordinary manœuvring duties, particularly for river and canal work, and in the great majority of cases a very large margin is allowed beyond this. The air is stored in solid-drawn or riveted air reservoirs which may be secured in any convenient position in the vessel, the only condition requiring to be met being that adequate drainage facilities are available, for which reason the reservoirs are given a slight tilt if stored in a horizontal position. The air compressors charging these reservoirs are of the three-stage type, and are arranged to compress the air up to 600 lb. per square inch. These compressors are run continuously during any periods when manœuvring is expected, so that the reservoirs are kept fully charged to meet all possible calls. The usual practice is that a certain percentage of the total air storage capacity is kept shut off from the main system so as to be available for contingencies. Periodic draining of the intercoolers for the compressors and very sparing lubrication of the pistons, are features which make for efficiency in the compressed-air system, and neglect of these items is liable to lead to trouble.

The practice adopted by some builders to increase the size of the engine-driven injection air compressor so as to deliver to the storage reservoirs is one which can hardly be commended as being good practice. A compressor, to give its best results, should be run in the neighbourhood of its full rating, and the reduced output necessitated by the fully-charged condition of the storage system alters the ratio of compression and increases the temperature of the air. The reduction in output is effected by wire-drawing on the suction stroke of the first stage.

A small emergency compressor is also fitted for use in the event of breakdown of the main set.

### Exhaust System.

The simplest system for the exhaust is by means of cast-iron piping, either heavily lagged or water jacketed, leading the gas from the cylinders to the exhaust silencer, from whence it is led either up the funnel, if one be fitted, or through separate uptakes. The arrangements of the silencer offers some scope for ingenuity. This usually consists of large tank which in itself is sufficient to absorb the major part of the vibration due to the pulsations, but additional features are frequently introduced to obtain more effective silencing, the principal methods followed being the fitting of baffles and of introducing a waterspray into the silencer, the forms being very varied. While the Diesel engine in its present form gives the highest thermal efficiency of any prime mover, the designer is not slow to take advantage of any opportunity of making use of any means whereby that thermal efficiency can be increased, and the utilisation of the latent heat in the exhaust gases affords opportunities in this direction. Perhaps the

(Continued on page 11.)

# MECHANICAL STOKING ON MERCHANT SHIPS.

## The Underfeed "Type E" Mechanical Stoker—Description and Application.

The news that the Dutch Koninklijke Paketvaart Maatschappy of Amsterdam, who have over 100 vessels, have adopted mechanical stoking with great success on two of their vessels, the ss. *Bintang* and ss. *Parang*, fitted with water-tube boilers, will render a description of the stokers used, the underfeed "Type E" stoker, a matter of considerable interest to marine engineers.

There seems to be no question of the success of the installations, which have had a thorough test, first in the North Sea on voyages between Holland, Hull, and Newcastle, then in a voyage to the Dutch East Indies, and, lastly, in trading voyages in the Far East, upon which the vessels are now engaged.

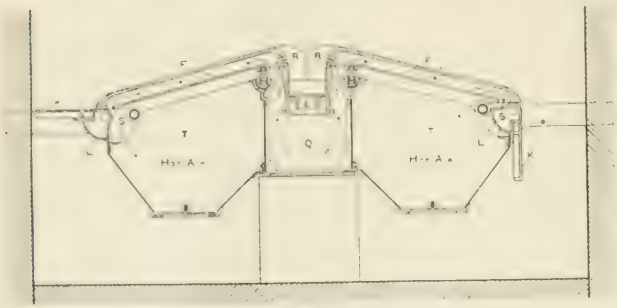


Fig. 1.—Section showing Central Trough.

The net results have been, on the report of Mr. Muller, the chief engineer of the company, to reduce the coal bill 10 per cent. to 15 per cent., as compared with sister ships hand-fired, and to give almost smokeless combustion, a mere "wisp" of smoke when going at full speed, with an average of 11 per cent. $CO_2$ as given by a $CO_2$ indicator. Another very great advantage of mechanical stoking is found to be that the steam pressure is maintained practically constant throughout, and equal in this respect to oil fuel. With hand-firing the furnaces have to be cleaned out every watch, so that there is invariably a considerable drop in the steam pressure, and, of course, in efficiency as well. A mechanical stoker, with the firedoors practically always closed, and a continuous feed of coal with an almost continuous discharge of ash and clinker, is, of course, bound to be an enormous improvement in this respect. Even with exceptionally bad clinkering coal as often used in the East, the clinker can be removed by hand through the firedoors without difficulty and without any diminution in the steam pressure. Finally, the introduction of mechanical stoking means a complete revolution in the labour conditions of the stokehold, which become also equal in this respect to those obtaining with oil-firing.

The underfeed "Type E" stoker is a coking stoker of very ingenious and unusual construction, but the details will be clear from the illustrations, Figs. 1, 2, 3, &c.

The coal is contained in a hopper, as usual, in front of the boiler, and it would be quite possible to feed the coal mechanically from the bunkers to this hopper. In fact, the Koninklijke Paketvaart Maatschappy have under consideration for the next new vessel an arrangement of this kind. The coal then falls through the bottom of the hopper and is conveyed along a deep central trough, or coking retort, the whole length of the furnace, as seen in Fig. 1, by means of a sliding bottom E moving slowly to and fro in the trough the full length. As the coal fills this trough E, it flows over and down each side of the inclined grates composed of bars F, which are, of course, parallel with the boiler front, the motion of the coal being partly due to gravity, but chiefly because each alternate inclined bar has also a slowly reciprocating motion urging the coal downward. The coal ignites in the trough E and cokes, the coking action being completed on the top of the inclined bars F, whilst the coked residue is completely burnt as it travels down the bars. The ash and clinker accumulates on the flat dumping plates K, which are fastened to the hinge bar L. This hinge bar can be lowered by means of a hand-lever, as shown in Fig. 1, at one side, the ash and clinker falling bodily down on to a platform, the floor of which is parallel with the lower ash doors, seen in Fig. 3, from where it can be raked out at leisure through these doors. The arrangement

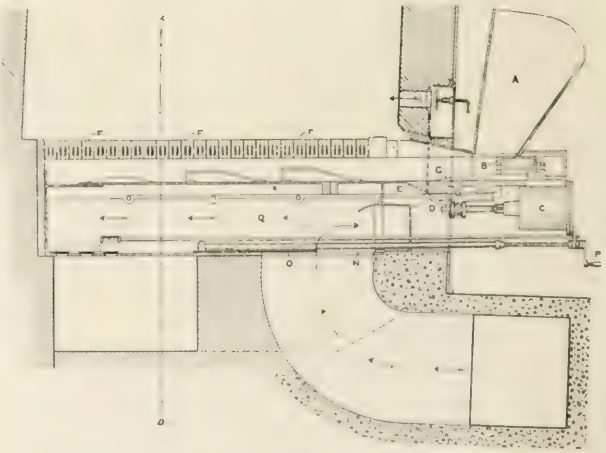


Fig. 2.—Sectional Elevation of Stoker.

is also clearly indicated in Fig. 2, A being the ash hopper and F the top of the inclined bars forming the central trough. The stoker is actuated by means of a steam piston C, the speed of which is regulated by a simple valve to within the limits of one stroke in three minutes to fifteen strokes per minute, each stroke corresponding to the movement of the sliding bottom E. The charge of coal per stroke is about 6 lb., the range of the coal feed, therefore being 120 lb. to 5,400 lb. per hour—a very wide range. The movement of the steam piston C is transmitted through the piston rod to the crosshead D, which is bolted to the sliding bottom E, whilst the small coal feed ram B

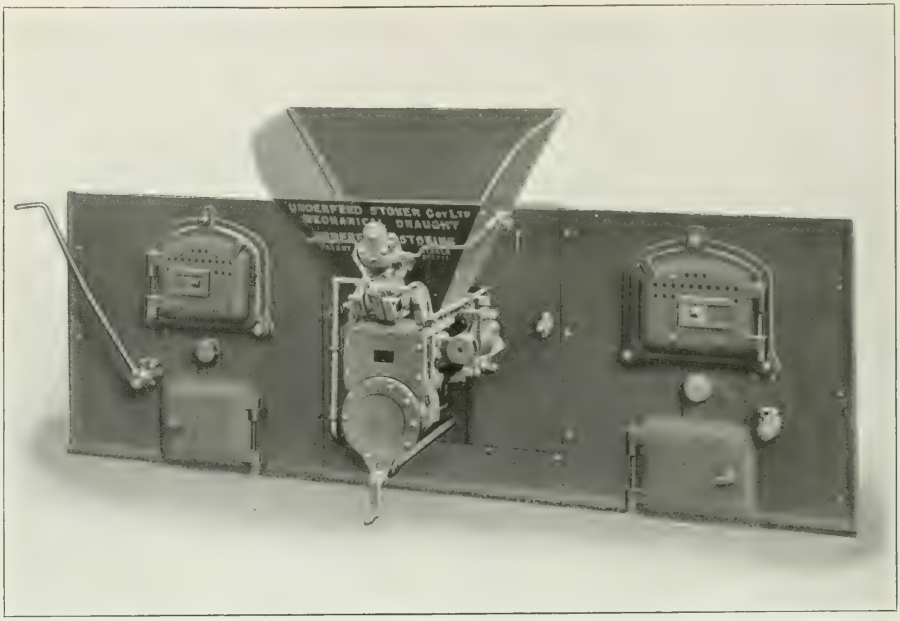


Fig. 3.—General Outlay of "Underfeed" Mechanical Stoker.

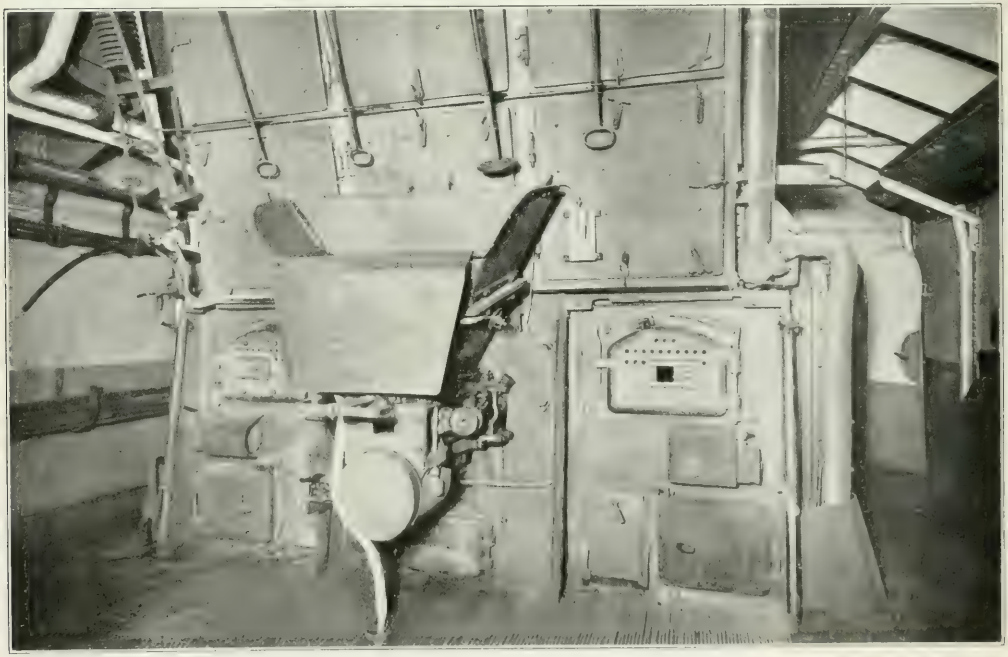


Fig. 4.—Stokehold of SS. "Bintoehan," showing Installation of "Underfeed" Mechanical Stoker.

is also connected to the pusher rod. When this ram B travels downwards it uncovers the bottom of the hopper A and allows coal to fall in front, which, on the return forward motion, is pushed on to the sloping bottom E and thus conveyed along the trough, which is soon filled, the contents flowing over on to the inclined bars F as already indicated. The bars F are alternately fixed and moving, being of slightly different design, the transverse travel of the moving bars being $\frac{1}{2}$ in. to 1 in., depending on the size of the stoker. The reciprocating motion of the moving bars is obtained, as seen in Fig. 1, by means of longitudinal rocking bars H, which are also connected to the steam piston C, and contains cams which engage with lugs on the bottom of the moving bars, as indicated.

The distribution of the air for this stoker is particularly ingenious, and is one of the chief causes of its efficiency. The air is supplied by means of a forced-draught fan, which enters an underground trunk, as seen in Fig. 2, being controlled by means of an air damper N operated by the handle P in the front. The air enters from this trunk through an adjustable aperture O into the wind-box Q, seen in Figs. 1 and 2, and passes upwards along the outside of the central coking trough. Part of the air is then discharged direct into the mass of fuel in the top of the trough through openings or tuyères R, Fig. 1, in the bars F, so that the combustion at this stage in the top of the coking trough is carried on by means of a forced blast of air. The remainder of the air then travels past the tuyères R and down inside the hollow fire-bars F, which have no openings in their top surface. The air, therefore, travels down the bars and cannot reach the fire-bars above until it has passed right through the bars and out of the aperture S at the bottom, from which it is discharged into the separate enclosed air chambers T underneath the inclined grate. The air then passes from these air chambers T between the moving bars F up into the fires above in the usual way and finishes off the combustion of the fuel as it travels down these inclined bars. The passage of the cold air in this way down the side of the bars F in the first place keeps them cool and prevents them burning out, whilst at the same time the temperature of the air is raised from 350° Fahr. to 400° Fahr. in the air chambers T, so that the combustion is finished off by means of a passage of hot air, a most efficient arrangement, the pressure in the chambers T being about $\frac{3}{8}$ in. W.G. These air chambers T are, of course, entirely sealed up from the main ash-pit, and there is no escape of air when the dumping plates K are dropped.

The power required to drive the stoker by means of the steam ram is about $\frac{3}{4}$ per cent. of the steam production of the boiler, whilst the forced-draught fan requires about another $\frac{1}{2}$ per cent., which is extremely low, and, of course, if the exhaust steam in both cases is condensed, the actual amount of steam required is almost nil.

Fig. 5.—SS. "Bintoehan," Donkey Boiler Smoke only, no Mechanical Feed.

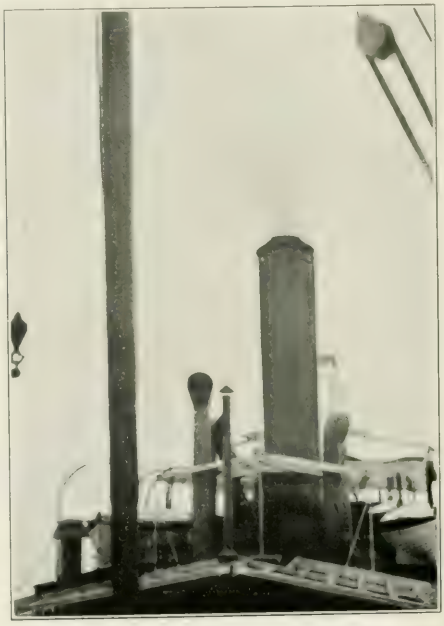


Fig. 6.—SS. "Bintoehan" at Full Speed (Mechanical Stoker in Operation). Note Absence of Smoke.

This stoker has already been in use for a considerable number of years on land, but for very large power-station practice it has been superseded to some extent by the new self-contained travelling grate underfeed stoker, since this "Type E" stoker cannot be made in sizes greater than a total width between the dumping plates of 13 ft., with 8 ft. 6 in. length, corresponding to 110 sq. ft. of grate area, at a normal duty of 30 lb. of coal per square foot of grate area per hour, with an overload possibility of 60 lb.

It will be remembered that some of the water-tube boilers now being installed on land are of enormous size, up to 100,000 lb. of steam per hour.

For marine work, however, the underfeed "Type E" stoker is highly satisfactory, because individual units are nothing like so great. As already stated, it is found in practice that this stoker works extremely well at sea, and because of the peculiar design there is no difficulty with the fuel on the grate, no

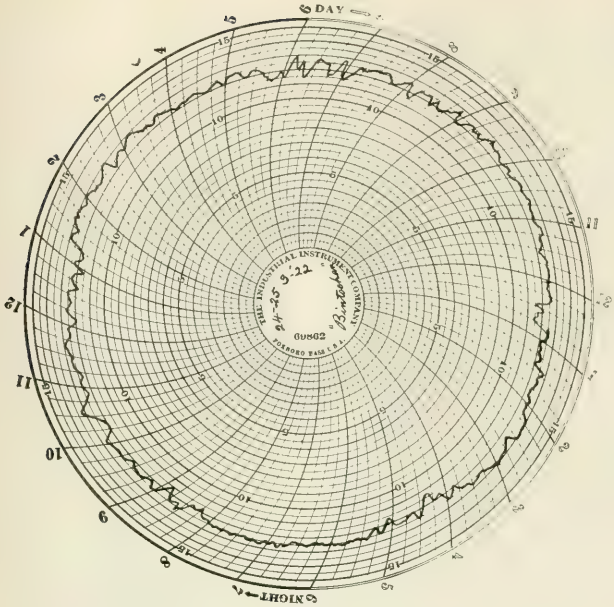



**Fig. 7.—Steam Pressure Chart (Note Regularity of Pressure).**

matter how rough the sea may be. Also the wear and tear on the hollow moving furnace bars has so far been found to be very small indeed, due to the efficient arrangements of cooling, as already described, with cold air. It would seem, therefore, as though a really important step forward had been made in the generation of steam for marine purposes.

### Oil-Fired Cable Steamer "Store Nordiske."

The Great Northern Telegraph Company recently received delivery of their new cable steamer *Store Nordiske* (Great Northern) from the builders, Akt. Nakskov Skibsværft, Nakskov. The vessel is 238 ft. 6 in. by 35 ft. by 23 ft. 6 in., has a gross tonnage of 1,456, and is propelled by a triple-expansion engine to which steam is supplied by oil-fired boilers, thus enabling steam to be raised at short notice for cable repair work. The equipment of the vessel has received special attention, particularly the cable appliances. The trial trip was run in the Great Belt, and gave every satisfaction with regard to speed and fuel consumption. The *Store Nordiske* is to be stationed at Shanghai, and on her outward voyage called at London to load the cable into her tanks.

## DIESEL MACHINERY AND ITS AUXILIARIES—(*Continued from page 7*).

most outstanding example of the way in which this can be accomplished is instanced in the Still engine, in which steam generated by the waste heat from the exhaust is returned to the prime mover, increasing its thermal efficiency and output. An interesting article on the utilisation of the waste heat for use in boilers raising steam for auxiliary purposes was reproduced in our October issue which described a boiler thus arranged in addition to being oil fired. Care would require to be taken in the design of the boiler to ensure that the action of the exhaust gas did not affect the oil jets. In the case of comparatively small quantities of steam being required, say for cabin heating and similar duties, where all electric auxiliaries are adopted, a special exhaust heat boiler of the Spencer-Bonecourt type seems to offer a suitable alternative. Additional uses to which the exhaust has been diverted is in the heating of fresh water for ship's use and in the galleys for cooking.

### Ship's Services.

No comment with regard to the bilge, ballast, sanitary or general service or other usual services common to the steamship is called for, these being in no way different from steam practice, and as such, familiar to all steam engineers.

### Refrigerating Plant.

This plant seems to be the only one outstanding in the way of internal machinery calling for any remarks. While not of considerable importance in the majority of vessels, the refrigerator is an essential in ships for the meat, banana and similar trades. Since, however, the safety of the vessel is vested in its Diesel propelling machinery, the safety of the cargo also might be entrusted to similar machinery, the refrigerating plant being operated electrically from current provided by Diesel or semi-Diesel driven generators. Beyond this, of course, the plant would not differ from existing practice.

### Deck Machinery.

Although, perhaps, a little out of the range of this paper, it is not altogether unfitting to touch upon the varying types to be found in view of their influence upon the actual engine-room arrangement proper.

The fitting of steam winches, with their heavy steam consumption, renders necessary comparatively large boilers for the generation of the steam, and it is therefore usual, where this type of machine is specified, to arrange for the ship and engine auxiliaries also to be direct steam-driven. While some saving in capital cost is effected by the adoption of steam winches, however, the economy in the electrically operated machines is so great and the advantages in other directions so varied, that careful consideration is required to decide the best arrangement. The direct-electric winch and the electro-hydraulic machines of the Hele-Shaw and Williams-Janney type are now beyond their experimental stages, and it is possible by their use to altogether discard the steam boiler for power purposes. The windlass and warping winches are also operated in a similar manner.

With regard to the steering gear, the only remaining unit for which power is required to be provided, the methods of operation available without the use of steam are the electro-hydraulic and the compressed-air systems, the former of which is a proved proposition independent of steam power.

# CAN THE "SCOTCH" BOILER BE IMPROVED?

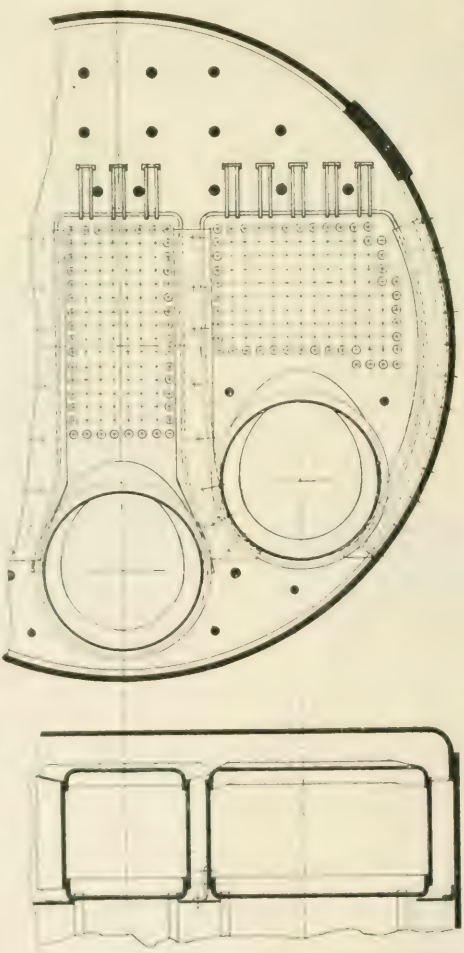
**Interesting Details of Alterations effected in the Scotch Boilers of a large American Yacht with Beneficial Results.**

The [illegible] marine boiler, generally known as the Scotch boiler, has [illegible] for over forty years and seems to have reached that stage of development [illegible] to suppose to be able to show in this article that it can be improved in such a way as to increase its efficiency considerably.

There has always been a tendency to prevent [illegible] irregularity in the circulation, and anything that will steady the circulation currents, or cause them to move in one direction only, will reduce this tendency to carry water over with the steam. Various forms of circulating devices have been fitted, outside the boiler itself, which take water from below the furnaces and return it to the boiler at a higher level, or from the front to the back, all of which, while minimising the trouble, do not entirely remove it, and prove that there is room for improvement in the design of this class of boiler.

Now, the cause of any current in the water inside a boiler is due to a difference of temperature, the hotter water rising and the cooler falling, so that the water below the line of the grates is always much lower in temperature than that between and above the tubes. This difference of temperature often causes very severe strains, especially when getting up steam from cold, so that seams in the neighbourhood of the heating and hence often need re-caulking.

The [illegible] surfaces in the boiler are the furnace crowns and the back plates of the back connections, so if no water can pass from the front to the back of the back connections in a horizontal direction near the level of the bottom of the furnaces to the level of the top row of tubes, a very rapid and energetic circulation is set up in a vertical direction between the sides and back of the back connections and the shell and back-end plates of the boiler, the only source of supply for this current being the water below and between the furnaces. It passes over the top of the back connections towards the front, passes downwards between the groups of tubes and between the outside vertical rows of tubes and the shell plates to supply the rising currents produced by the furnace crowns, the tubes and the back-plates of the back connections. This current is set up as soon as the fires are lighted, it is always in the same direction and is maintained as long as there is any fuel burning.



"Scotch" Boiler fitted with Special Circulating Baffles.

The necessary baffle plates can be secured, as shown in the accompanying drawing, by angle irons to the shell plates and rest against the front tube-plates of the outside back connections, as a watertight joint at this point is not a necessity. Between adjacent back connections the baffle plate is secured by means of stays riveted to the wrapper plate of one, and rests against the tube plates of both. The baffle plates cause no temperature strains whatever, and do not interfere with the sealing of the boiler. A large steam yacht, built at Wilmington, Del., U.S.A., had four boilers with two furnaces in each. One of these boilers was fitted with baffle plates, as described, but the other three were left without any. When in commission the following results were obtained: When raising steam from cold the fires had to be lighted in the three boilers without the baffle plates one hour before the fires were lighted in the remaining boiler, in order that all four should show steam at the same time. When steaming at 10 knots, the boiler with the baffle plates could furnish all the steam the engines required, whereas two of the other boilers were necessary for the same service, one alone could not be made to supply steam enough; moreover, it primed so much that there was danger of wrecking the engines. The one boiler fitted with the baffle plates was never known to prime, not even in rough weather. When cruising, the yacht would often stay at a port for a week or more at a time, fires being raked out and the boilers allowed to go cold. When getting up steam again the boilermaker always had to do some re-caulking to all three boilers not fitted with baffle plates, the other one never required anything doing to it during a two years' cruise around the world.

The above particulars were obtained from the chief engineer at various times when the vessel happened to be at New York, from which it would appear that, amongst other advantages, owing to the rapid circulation and the constancy of its direction, practically all parts of the boiler are at the same, or nearly the same, temperature.

# THE DESIGN OF BELL-MOUTH SUCTIONS.

### Their Application to the Discharge of Liquids in Bulk.

The following article is intended to apply mainly to oil tankers where an efficient pumping arrangement is essential if detention in port for the discharge of cargo is to be cut down to a minimum. Fig. 1, showing a bell-mouth, adjacent piping and control valve, indicates the general arrangement usually adopted. Complete drainage of the cargo tanks is the ideal condition to be aimed at, and, accordingly, too much care cannot be given to the design and location of the bell-mouth suctions. Where practicable they should be placed as near as possible to the after-end and middle-line bulkheads of the tank, as shown in Fig. 2, so that when the vessel is trimming by the stern, due to the discharge of a forward tank or otherwise, the dregs of cargo left in any particular tank will gravitate to the suction bell-mouth. These suctions are invariably led from the main suction line in a horizontal direction, and this obviates the necessity of fitting doubling plates under the feet of the bell-mouths in virtue of the fact that, in the event of the vessel grounding, there would be sufficient spring in the line of piping to prevent their feet piercing the shell plating in their vicinity. Fortunately, the absence of the doublers referred to above allows of a more perfected degree of discharge by permitting the bell-mouth to sit directly on the keel plate, which should be a raised strake of plating and, therefore, the lowest level of the tank.

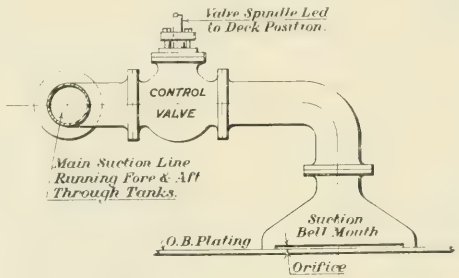



**Fig. 1.—Bell-Mouth and Associated Fittings.**

The next consideration is the determination of the proportions of the bell-mouth, having in mind the various local conditions to be satisfied; in any case, the fore-and-aft width should be kept as small as practicable. The athwartship length of the bell will be governed mainly by the diameter of the suction line and the depth of the orifices at its base. The latter should not exceed the thickness of the sunken garboard strake of plating and, as a maximum, should be limited to about $\frac{1}{2}$ in. or $\frac{5}{8}$ in. In determining the area of the inlet orifices, ample allowance must be made for the contraction of flow through them, and continuous easy stream lines should be aimed at in arranging the body of the bell-mouth. By rounding the outside of the edge of the orifice, as in Fig. 4, the contraction of the inflowing jet during discharge is diminished, and by rounding the inner edge, as in Fig. 5, the stream lines are encouraged to take an upward course, which in consequence reduces the internal frictional and eddying resistances. For efficient discharge, and bearing in mind the uncertainty of the degree of contraction of an orifice with rounded edges, the collective area of the various orifices should not be less than 20 per cent. over and above the cross-sectional area of the bore of the main suction piping.

In order to minimise the size of the bell-mouth, an internal passageway with side orifices may be arranged to run throughout its length, as illustrated in Fig. 2, which arrangement, according to the writer's views, represents efficiency in bell-mouth design. If necessary, more than one internal channel may be introduced to satisfy prevailing conditions.

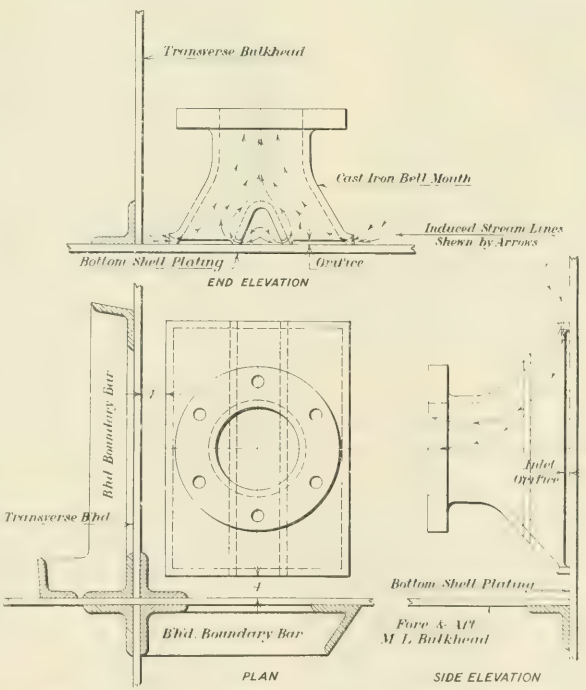



**Fig. 2.—Position of Bell-Mouth relative to Ship's Bulkheads.**

Fig. 6 shows details of the bell construction in way of the suction orifices. The lip formation makes it possible to increase materially the radius of curvature of the mouth of the orifice and results in easy and efficient stream lines. The total length of inlet orifices may be simply estimated after having judiciously decided upon the depth. Thus,

Let $d$ = the depth of orifices in inches.

Let $x$ = the internal diameter of the suction line in inches. Then the necessary collective length of orifices L inches is given by

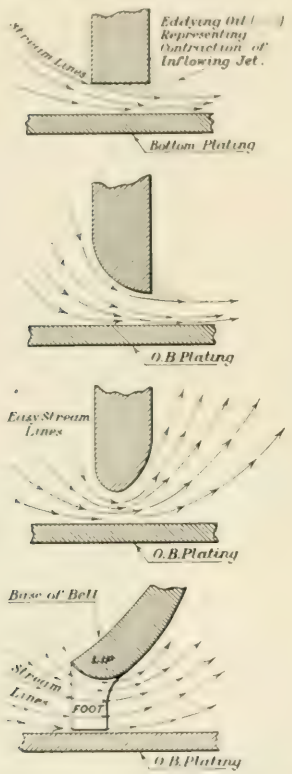
$$L = \frac{x^2}{d} + 20 \text{ per cent.},$$

i.e., $L = 0{\cdot}94\,\frac{x^2}{d}$ inches.

Large bell-mouths are usually of $\frac{1}{2}$ in. to $\frac{5}{8}$ in. cast iron, provided with an inspection door. During installation the upper flange should be carefully machined after marking off in place, and a substantial cardboard jointing ring smeared with soft soap inserted between this and the corresponding

flange on the wrought-iron suction line pipe connected thereto, and the whole hove up perfectly tight.

The after flange is frequently screwed on the end of the




**Figs. 3, 4, 5, and 6.—Influence of Profile on Stream Line Flow.**

pipe and, to ensure satisfactory results, it should be well caulked, and the whole finally subjected to an adequate hydraulic pressure test.

## GEARED TURBINE INSTALLATION WITH MACALPINE FLOATING FRAME.

We reproduce on page 29 a photograph showing the turbine and gearing for the oil tanker *British Commander*, erected on the test plate of the machinery builders, the Metropolitan-Vickers Electrical Company Limited. The *British Commander* was owned by Tankers Limited and she was built by the Caledon Shipbuilding & Engineering Company Limited. The machiery is a double-reduction geared installation of the Rateau impulse type and develops 3,200 s.h.p. The gearing is of the three-box double-reduction type with Macalpine floating frames on the high-speed and intermediate pinions. The first vessel to be fitted with this type of gearing in this country, the ss. *British Grenadier*, is now at sea and giving every satisfaction. It is interesting also to note that Metropolitan-Vickers Limited have in hand two sets of twin-screw turbine and single-reduction gearing (*i.e.*, four sets in all) for two ferry-boats building for the Imperial Japanese State Rail-

## M.S. "ARIZONA."

The motorship *Arizona*, an illustration of whose engines is given on page 30, was built to the highest class of Bureau Veritas for the United Shipping Company, of Copenhagen, the hull being constructed by the Nakskov Shipyard, Nakskov, Denmark, and the machinery built, delivered and installed by Burmeister & Wain, at their yard in Copenhagen.

The principal dimensions and other particulars of the vessel are :—

| | |
|---|---|
| Type of ship | Cargo. |
| Length between perpendiculars | 405 ft. |
| Breadth, moulded | 54 ft. |
| Depth | 36 ft. 6 in. |
| Draught, loaded | 26 ft. |
| Deadweight capacity | 9,100 tons. |
| Stipulated normal average speed at sea | About 11 knots. |
| Stipulated normal consumption of fuel oil per day | 9 tons. |
| *Machinery* | |
| Type of machinery | Burmeister & Wain's 6-cyl. 4-cycle. |
| Number of main engines | 2 |
| Cylinder diameter | 590 mm. |
| Stroke | 900 mm. |
| Revolutions per minute | 140 |
| Indicated horse-power | 2,800 |
| Brake horse-power | 2,200 |

The trial results, over the measured mile in the Sound, on November 17, 1922, were :—

| | |
|---|---|
| Indicated horse-power, average | 3,132 |
| Revolutions per minute, average | 144·5 |
| Speed, average | 11·215 knots. |

During the consumption test, the main engines developed 2,873·6 i.h.p. at 141·4 r.p.m., on a fuel oil consumption of 141·21 grammes or 0·311 lb. per i.h.p. hour, net calorific value being 10,000 kg. cal. (18,000 B.Th.U.), including the consumption of auxiliary engines producing the necessary current for the auxiliary machinery, steering engine and electric light.

The machinery is placed amidships and is of Burmeister & Wain's standard type for twin-screw ships. The main engines are short stroke, forced lubricated cross-head engines on the front end, fitted with three-stage air compressors supplying the necessary injection air for atomising the fuel oil.

All auxiliary machinery in the engine room, as well as the deck machinery, is electrically driven, the necessary current being supplied by three 50 kw. Diesel dynamos. The voltage of the current is 220 volts, and for the lighting purpose it is transformed down to 110 volts by means of a motor generator.

Each of the generators is sufficient for supplying the necessary current under normal working conditions at sea, whereas two or all three generators have to be started when the consumption of current is large, *e.g.*, when manœuvring with the manœuvring compressor running, or when loading or discharging, the winches using much current.

The heating is effected by means of steam produced in a small cross-tube boiler, this boiler also being able to deliver steam for fire-extinguishing in holds.

The *Arizona* is the fourth motorship in the fleet of the United Shipping Company, Copenhagen, the other three motor ships also being furnished with Diesel engines by Burmeister & Wain.

After the successful trial trip, the ship started her maiden voyage for South America.

"The Organisation of a Trans-Atlantic Passenger Liner" is the title of an address which Mr. A. D. Mearns, director and general manager of the Cunard Line, delivered on December 21, at the Liverpool University, under the joint auspices of the University and the Institute of Transport.

# THE RAMSAY MARINE GOVERNOR.

**A New Departure—Application to Internal-Combustion Engines—Method of Operation.**

The Ramsay marine governor and its application to the marine steam reciprocating engine is now well known. It is worthy of note, however, that in view of the increase in the number of internal-combustion engines constructed for marine propelling purposes during the last few years, the patentees of the governor have decided that a further field has been opened up for them, and they have accordingly placed on the market a specialised form of apparatus which will be applicable

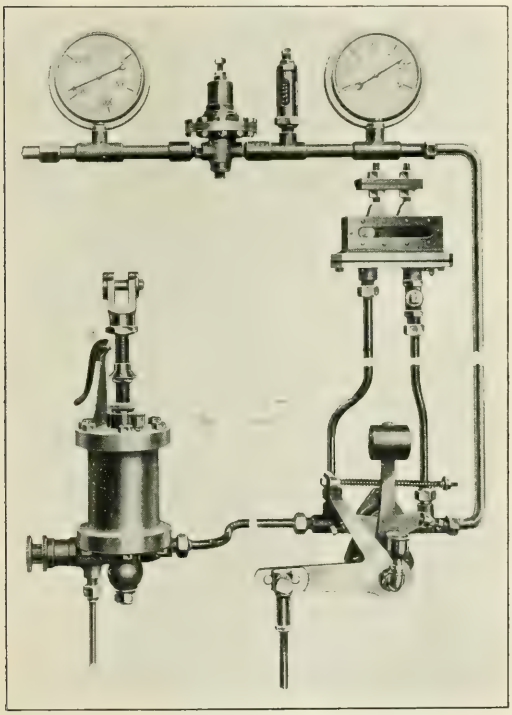


**Fig. 1.—General Outlay, showing Reducing Valve for Compressed Air.**

to such engines. In the absence of apparatus more suitable for marine requirements, many of the governors on such engines have been of the centrifugal type. The new type of Ramsay governor, however, enables a ship to have the advantages of the anticipating "anti-race" governor enjoyed by the correspondingly fitted steam-propelled vessel. It has been argued, that, owing to the "steadying" action of the flywheel fitted to internal-combustion engines, a governor is unnecessary; against this, however, we have the undisputed fact that the sudden decrease of load on the engine when the screw or screws lift from the water causes abnormal crankshaft strain, which is accelerated rather than decreased by this very reluctance of the flywheel to respond to the sudden impulse. As with the "steam" governor the "internal-combustion" governor consists essentially of two parts—anticipating and emergency. The working medium in this case, however, has of necessity to be compressed air, since, of course, there is no condenser vacuum available. In order to be available for use in the piston, the compressed air can be made, if necessary, to pass through a specially arranged reducing valve, shown in Fig. 1, which gives an idea of the general outlay of the apparatus. Fig. 2 shows in greater detail the anticipating valve, the inertia valve, and the operating cylinder.

The anticipating valve comes into action automatically as the lift of the ship's stern brings the propeller near the surface, causing the operating cylinder to reduce the fuel supply to the cylinders before the propeller is exposed, and to re-open the supply immediately the propeller is re-immersed. It consists

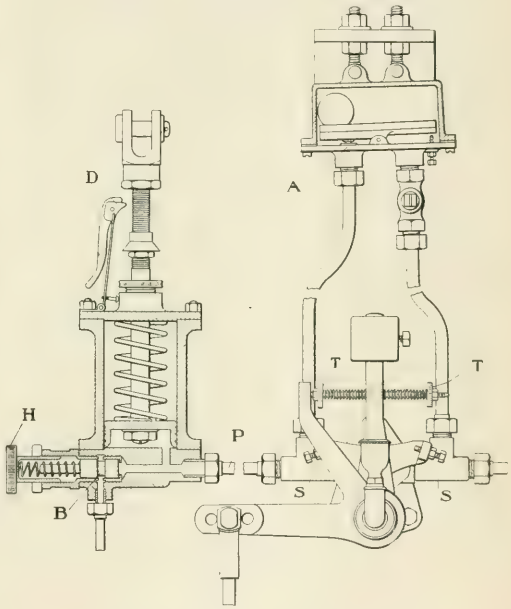



**Fig. 2.—Part-Sectional Elevation.**

of a closed box (Figs. 1 and 2) suspended on the engine in the direction of the keel, containing a rocking valve controlled by a rolling ball, and is connected to the compressed air service. By means of the adjusting bolts above the casing the valve box is set at the required angle to suit the trim and draught of the ship. When the pitching of the vessel causes the ball to roll forward the valve "A" is opened and pressure allowed to pass to the operating cylinder. Similarly the valve is closed as the propeller is re-immersing.

The inertia valve consists of a double-acting valve in the pipe service between the pressure supply and the operating cylinder. The valve is operated by the engine through a weighted lever balanced between two springs of equal tension and connected to a reciprocating driving lever.

The tension of the springs is set by means of the thumb

[illegible] so that at the pre-determined speed the weighted lever will swing between the stops "S" on the valve facing [illegible] and its motion will leave the valve in the closed position. Immediately the speed of the engine is increased from any cause by 2 per cent. or more, the increased momentum given to the weight lever causes it to strike the stops and so open the valve and allow the pressure to pass to the operating cylinder.

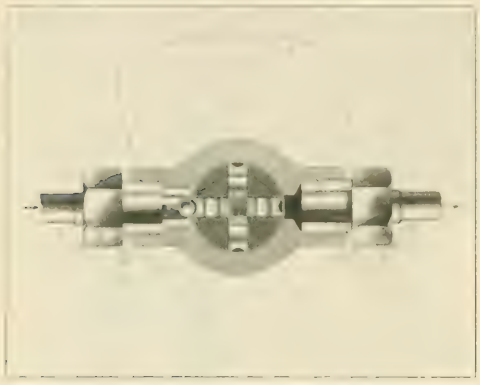


**Fig. 3.—Emergency Control Cut-off Valve.**

As the speed of the engine returns to normal, the weight lever becomes inoperative and the valve closes, so cutting off the supply of pressure to the operating cylinder, and allowing the operating piston to resume its inoperative position. The reason for this governor being ultra-sensitive is that it is operated by either the upward or downward stroke of the engine. All other impact governors known act only one way, usually on the downward stroke of the engine.

The operating cylinder is fitted so as to operate the fuel pump valve lever to any required degree. The piston in the cylinder is held in the open position by a spring resistance.

The inlet to the cylinder is provided with an adjustable and automatic by-pass valve "B" (see Fig. 2), and it is this which constitutes quite a remarkable feature of the governor, inasmuch as, by means of it, the travel of the piston can be varied to any required distance within $\frac{1}{8}$ of an inch. The piston in the by-pass valve operates against a spring, the tension of which is adjusted by means of the hand-wheel.

When the valve is set by the engineers in charge, the piston can be relied upon to travel and remain constant at exactly the same part of its full stroke, whether $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., and so on, at each operation of the governor, and by turning the hand-wheel such alterations to the stroke of the fuel pump valve lever which in other conditions to the normal might be found necessary are made.

When either the anticipating valve or inertia valve allows pressure to pass to the operating cylinder it is admitted by the pipe "P." The by-pass valve allows sufficient of the pressure thus admitted to leak away as is necessary to hold the piston, and consequently the fuel pump valve lever in the required position. When the anticipating or the inertia valve shuts off the pressure, the spring in the cylinder returns the piston to the open position, and in doing so puts the fuel pumps in the original working position.

The piston rod is provided with an adjustable sentinel detent "D." This constitutes a locking device which will cause the engine to be brought to a complete stop in the event of a serious accident—for example, a broken shaft or stripped propeller. Should the racing be excessive, as would result from such accidents, the proportionate excess of pressure admitted through the inertia valve would cause the piston in the by-pass to travel further over the outlet orifice and reduce or completely shut off the leak. The piston in the cylinder would then travel to its full extent and be locked by the detent.

The detent spring is provided with a trigger for releasing the detent by hand after engagement.

It is interesting to note that should it be judged necessary, the anticipating part of the device can be fitted without the inertia device, although it is usual to fit the two together. The complete outfit is small and compact, weighing approximately 35 lb.; it represents a noteworthy attempt to bring a useful "auxiliary" in line with the very latest departure in the science of marine propulsion, and we would certainly recommend it to the notice of either present or prospective motor-ship owners.

## UNITED STATES DIESEL-ELECTRIC FERRYBOAT "GOLDEN GATE."

We show on page 29 an illustration of one of the two 750-h.p. direct-current main propelling motors for the new Diesel electric ferryboat *Golden Gate*. The vessel is of the double-ended type, and has the distinction of being the first Diesel-electric ferryboat to go on service. Designed for fast ferry service across San Francisco Bay between San Francisco and Sausalito, the new vessel is 220 ft. long, and is fitted with a single propeller at each end. Her main propelling machinery consists of two 500-b.h.p. Werkspoor Diesel engines, each driving a 360-kw. 250 volt direct-current generator. Power from the generators is delivered to two 750-h.p. electric motors, one on each propeller shaft.

The electric drive has been considered particularly suitable for service of this nature, which involves fast runs through crowded harbours and against strong currents, and the increased manœuvring ability is likely to prove a considerable advantage. In ferryboat work experience has shown that the best results are achieved when the stern propeller is used as the propelling medium, and in the case of the *Golden Gate* the provision of two mechanically independent motors enables the most desirable power distribution to be attained.

While the stern propeller is made to work at full power the bow propeller is caused to rotate at a reduced speed which experience shows to give the minimum amount of "drag." For this purpose the bow motor is run as a "pilot" motor at the desired speed by an automatic setting on the control panel. With the electric drive only the speed of the motors need be altered, and on trial it has been demonstrated that this can be effected in the matter of a few seconds.

## EXAMINATION PORTS AND DAYS.

The Board of Trade have decided, with a view to economy and efficiency in the conduct of the examinations of engineers, to hold them at a smaller number of ports than hitherto.

On and after February 1, 1923, examinations will no longer be held at Greenock, West Hartlepool, Bristol, and Londonderry, but additional examinations will be held at Glasgow. At Cardiff, examinations will be held in the fourth and fifth weeks of the month; at Hull and Leith, examinations will be held monthly; and the times of the examinations at Dundee will be altered.

# INTERNAL COMBUSTION AND THE SPECIFIC HEAT OF GASES.

**Lack of Theoretical Knowledge on the Subject compared with the Advance of Practice. The Necessity for Further Information.**

The manufacture of internal-combustion engines, whether for ships, for stationary purposes or for vehicular traffic, though enormously developed as regards the practical aspect during the last decade or so, has been unaccompanied by any corresponding development in our knowledge of the more theoretical aspects of what actually transpires in the engine cylinder, and though more attention would appear to have been devoted recently to this matter, both in laboratory practice and at some of the scientific societies' meetings, there is, unfortunately, little doubt that on the very fundamental question of heat of combustion and heat flow through cylinder walls, jackets, covers, &c., extensive or exact information is still seriously lacking. In many respects, precise knowledge of the specific heat of gases is deplorably scanty, and while it is perfectly easy to manufacture internal-combustion engines of very high efficiency in spite of this fact, it is, nevertheless, indisputable that until this data is put on to a more satisfactory basis, substantial progress in design will undoubtedly be handicapped. One has only to turn to the history of the determinations of the properties of steam, and particularly to those of the specific heats of superheated steam, to find a remarkably parallel state of affairs to that now existing in the case of the gases due to internal combustion, and particularly those of oil.

## Steam.

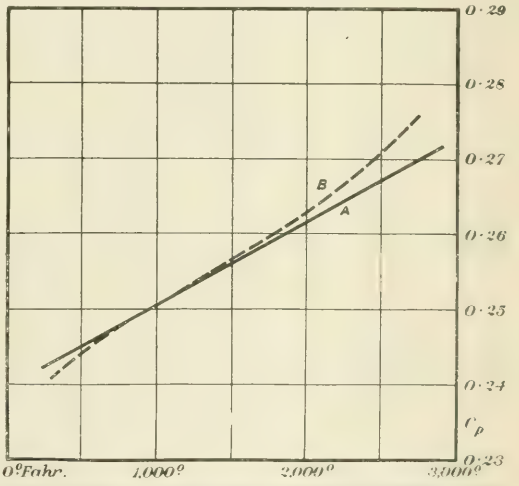
It is certainly correct to take the view that many a very highly efficient steam turbine was in operation long before the latest and most authoritative researches on steam were given to the world by Professor Callendar in his convincing volume, published last year, in which figures for the properties of steam possessing marked divergences from previous publications will be found, and it is probably not too much to assert that steam turbines of practically identical efficiency could be designed from almost any of the books on steam published during the last five-and-twenty years, although in many respects the tabulated figures may vary considerably. The more exact determinations of the specific heat of superheated steam as it varies with both pressure and temperature, however, have in many cases necessitated the somewhat laborious revision of much existing information on heat transference and efficiency of superheaters in view of the extent of their variations from previous practice. This is precisely the situation in which the theory of the internal-combustion engine, as regards the explosion portion of the cycle, is likely to find itself, unless the values of the specific heat of the gases most generally involved are checked apart, and, as regards the problem of the gas turbine, this information is even more necessary as the efficiency of that still elusive prime mover is far more dependent on accurate knowledge of stage-by-stage heat drops than can ever be the single-cylinder explosion engine. Most engineers are conversant with the numerous books on the properties of steam, from Regnault's figures at one end to Dr. W. J. Goudie's recent interpretations of Professor Callendar's figures.

## Other Gases.

When, however, information be sought as to the corresponding information for gases, what do we find? Not only wide variations similar to those that, until very recently, made most superheater analyses of doubtful accuracy, but also assumptions that certainly require to be very thoroughly overhauled before they can much longer be accepted. Very little work has been done on the subject of the variation of specific heat with pressure: experiments on some gases have been taken up to very high temperatures, while information on others is less accurately known, and in the case of constant volume determinations there are considerable divergences between the figures given by various experimenters. The system of experiment alone has often varied widely, and this fact has tended to introduce discrepancies of its own. The divergences are, perhaps, really more aggravating than serious in some respects, but the fact remains that various problems are still in want of actual solution and that until unquestionable determinations of specific heats for certain gases are available, there must always remain an element of doubt about the intricacies of high pressure and temperature combustion.

## Investigators.

Ever since 1883, when Mallard and Chatelier published their paper in the *Annales des Mines* on "Experimental and Theoretical Investigations on the Combustion of Explosive Gaseous Mixtures," many investigators have been attacking the same subject, but it embraces wide and difficult problems, and in spite of the lapse of time it is hardly surprising that complete solutions are still far from having been achieved. This paper was really a very condensed summary of a series of others published at various times, whether in the *C.R. de l'Académie des Sciences*, the *C.R. de la Société de Physique*, the *Journal de Physique* or in the *Bulletin de la Société Chimique*. Further published data recording the results of experiments on very similar lines was given by Langen in the *Zeitschrift des Vereines Deutscher Ingenieure* in 1903, and although considerably improved apparatus was used, these results, which were carried up to temperatures exceeding 3,000° Fahr., closely confirmed Cha elier's, although Langen's figures for the specific heat of $CO_2$ and $H_2O$ did not increase quite so rapidly at the high temperatures as did those of the French scientist. Like both Chatelier and, later, Langen, Pier, whose experiments were published in the *Zeitschrift für Elektrochemie* in 1910, also used




*Curve A Refers to an Oil Fuel with Carbon 85% Hydrogen 13·5%, and an Excess Air Factor of 1·8.*

**Fig. 1.—Curve of Specific Heats of Internal-Combustion Mixtures.**

a bomb in which the explosion was effected. All three, however, used different forms of measuring apparatus. Berrum's experiments on the dissociation and the specific heat of $CO_2$ were carried out at very high temperatures by the explosion method also, but they introduce little beyond corroborative evidence of the close accuracy of Chatelier's original figures. A full résumé of all these experiments was published in the *Revue de Metallurgie* by Damour and Wolkowitsch early last year.

### Haber's Thermodynamics.

Probably the best descriptive account of specific heat measurements will be found in Haber's "Thermodynamics of Technical Gas Reactions," but the last edition of the English translation was published more than twelve years ago. Perhaps the most exact values of specific heats were those obtained by Holborn and Hennig, in Germany, in recent years, a different method being used, but one which is nevertheless open to some criticism. These experiments were carried out up to a temperature of 2,400° Fahr., and can reasonably be extrapolated for the extra range found in internal-combustion work. But in all of these the determinations of specific heat were made at constant volume and varying temperature. The amount of work hitherto conducted on the variation of specific heat with pressure is very small. In 1914, and again in 1917, the *Z. d. V.D.I.* contained an account of experiments on the variation of the specific heat of air at 60° Cent. between one and 300 atmospheres carried out by Holborn and Jakob, the variation being

$$Cp \times 10^4 = 2414 + 2{\cdot}86p - 0{\cdot}0005p^2 - 0{\cdot}00001106p^3$$

### Variation of other Gases.

It was considered probable that the variation of other gases would be of a similar nature. Now, up to the limits of pressure found in internal-combustion engine work, this indicates an increase of $Cp$ with increase of pressure, and all experiments on variation with temperature do likewise. Generally speaking, it may be accepted that for $CO_2$, water vapour and nitrogen, Chatelier's figures are fairly accurately recorded up to the temperatures met with in internal-combustion engine work, those for air, hydrogen and oxygen, are not so precisely known; while those for CO are generally accepted as being the same as for nitrogen. Over a wide range of temperature, say, 400° to 2,800° Fahr., the increase in values of specific heat for oxygen, nitrogen and CO is comparatively small, being only of the order of 7 per cent. or so. The increase in the case of $H_2O$ may reach 20 per cent., while the value for $CO_2$ increases from less than 0·20 to more than 0·28. Exactly how far these may be modified by the effect of pressure is not accurately known, but indications point very strongly to a greater deviation from a straight line increase than has previously been assumed. That is to say, that over a very wide range it seems most likely that the curve of specific heats of internal-combustion mixtures actually tends to assume the general shape of the dotted line B in the sketch rather than the more nearly straight full line A, characteristic of general acceptance at the present time, on account of the pressure effect being ignored. It is true that about the middle of the line no serious error is involved in accepting the almost conventional figure of $Cp = 0{\cdot}25$ for rough and ready purposes. It is at the top end where the increase in value is becoming more apparent that further corroborative determinations are desirable, because the calculation of temperatures (and the subsequent estimates of heat flow through cylinder walls, &c.) from indicator diagrams may readily be affected to the extent of 10 per cent. or more by the lack of precision surrounding the determination of the $Cp$. With oil fuel, the variation is, of course, greater when high percentages of carbon and hydrogen content are involved and when the excess air factor is low. Conversely, when the former are both low in percentage and the excess air factor high, the influence of the lower rate of increase of value of $Cp$ for oxygen and nitrogen tends to leaven the variation of the whole mixture. At the lower temperatures met with in Diesel engine exhausts, little error is involved, but in assessing the value of the waste heat for steam-raising purposes, or for compounding, or for use in exhaust turbines, &c., the quantity available is apt to be exaggerated. In dealing with boiler practice and furnace gases the range of pressure under the highest forced draught is obviously negligible, but in Diesel engines it may range from 600 to 40 lbs. absolute or, say, $\frac{p^1}{p^2} = 15$, and in gas turbines, when it is confidently anticipated that low final pressures may be utilised, the range may, perhaps, eventually be found to run to double this ratio.

It is often held to be inadvisable to alter established cases of comparison during development work, and in many cases it is undoubtedly better to adhere to a given standard of measurement, although the standard itself is known to be lacking in precision to some undetermined extent. Thus, for instance, adherence to the Froude frictional constants for ship resistance, or to the assumption that the frictional resistance of a ship-shaped body was proportional to that of a flat plank of the same area and length in direction of motion, was continued long after both were known to embody material error. There is not the slightest doubt that to embark on a fresh series of experiments on the specific heat of gases will involve a long, arduous and costly amount of work, and the question naturally arises as to whether it is worth it at the present time. Practice has almost invariably preceded theory in this respect, and though apparently research on this problem was being conducted in Germany during the war period, there is no doubt that during that time investigation of this very problem was severely restricted in other countries. There is an increasing tendency to study much more closely than was previously possible what exactly occurs during the combustion period in internal-combustion engines, particularly those of large size, which are necessarily restricted in cylinder dimensions by this question of heat-flow per unit of cylinder surface. In the case of single-shaft land turbines, errors in calculation of heat drop per stage, though frequent, were less readily noticeable than they afterwards became in the early days of marine work, when wide variations of power on different shafts, where equality had been anticipated, were of common occurrence. A good deal of controversy arose over the expansion line to follow in design, and it was not till much wider use of the entropy chart became general that these were eliminated. Unfortunately, while a single chart suffices for steam, a wide variety are needed for internal-combustion work, owing to the variety of mixtures and proportions of the chemical constituents of the fuel. But the fact remains that at present we do not seem to possess a sufficiently accurate or uniform series of determinations of the specific heats of various gases to enable these to be calculated for general use, and it seems only too clear that for some time to come engineers will have to continue to use *tot homines, quot sententiæ* charts of their own evolving, based on their own choice of values of $Cp$, until such time as a more authoritatively established series is available.

SPONTANEOUS COMBUSTION IN BUNKERS.—Mr. A. E. Findlay, B.Sc., F.I.C., delivered an interesting lecture before the members of the Liverpool branch of the Marine Engineers' Association on "Spontaneous Combustion in Bunkers and Cargoes." Mr. Findlay remarked that combustion might take place slowly, quickly or explosively, and showed what conditions were necessary before combustion could take place. It was also shown that substances having very low temperatures of ignition were produced by the decomposition of coal, and that coal gas itself could be ignited by a spark. All causes of powdering and heating would be contributory in producing spontaneous ignition, and such contributory effects with regard to coal bunkers and ships' holds would be (1) handling; (2) oxidation of pyrites; (3) crushing by pressure; (4) friction due to roll of vessel; (5) proximity of bunkers to boilers or engines.

# MARINE DIESEL ENGINES—RUNNING CONDITIONS AND OPERATING SYMPTOMS.*

**Watch-Keeping—Points to be Observed at Platform—Compressors—Starting and Manœuvring.**

For the successful operation of the machinery in a motor-ship, or for that matter, in any ship, it is essential that the chief engineer should know the exact condition of each constituent part and what service it is capable of before needing overhaul. This information is invaluable, not only from the point of view of reducing the amount of work done in the engine room, and so lowering maintenance costs, but also because, in the event of trouble occurring, much time is saved by eliminating unlikely causes, while the location of the source can be more readily effected. To achieve this knowledge may entail a certain amount of extra work at the start, but it is labour that will be amply repaid.

Considering first the main engines, some time after "Full speed" has rung at the beginning of the voyage and the engines have settled down for a run of several days, a set of indicator cards, both normal and light spring, should be taken, while all data relating to them should be accurately noted. After a power card has been taken from each cylinder, the blast air and fuel should be shut off from each, one at a time, when a compression card can be obtained. All these cards should be carefully compared and the characteristics of each noted, when a good impression can be formed of the condition of the engine at the time.

Some time within 24 hours of reaching port another set of cards of each type should be taken and compared carefully with the ones taken at the beginning of the trip. Weather conditions must, of course, be taken into account, and due allowance made for variation.

## Attention to Valves.

On arrival in port at the end of a long run, a point should be made of checking all cam roller clearances and noting what differences exist from the original settings. When comparing these settings, the two lots of indicator cards should also be referred to, when the "cause and effect" may become apparent.

At this time it is also advisable to test all the valves in the cylinder head and the piston rings as well, to ascertain the true condition of each, and the findings should be carefully logged for future reference and comparison. This testing can be done by means of blast and starting air. The indicator cocks on all cylinders should be opened; then, if blast air is admitted to the fuel injection valves while the operating gear is in the neutral position, by listening at the indicator cocks any fuel valve that is leaking can be detected by the noise of the air blowing into the cylinder. Starting air valves can be checked in a similar manner, also by admitting air to them when in the "off" position. To test the exhaust or any other valves that may be in the cylinder head the manœuvring gear should be put in the neutral position and the indicator cock shut, when, if air be admitted to the cylinder with the crank on T.D.C. by propping open the fuel injection or starting air valves, any leakage that exists can be detected by listening at (1) the air intake pipes in the case of inlet valves; (2) the exhaust pipe test cocks in the case of exhaust valves; (3) the escape port in the case of relief valves, while piston-ring tightness can be ascertained by listening at the bottom of each cylinder.

A certain amount of this work of testing is in the way of being additional labour, since the approximately true state of each valve can be ascertained from the indicator cards and operating symptoms. However, as a method of gaining a thorough knowledge of reading indicator cards and operating symptoms it is fully justified, while from the point of view of knowing the exact state of each part involved, it is invaluable. This latter knowledge cannot be gained solely from indicator cards, since these only denote approximate conditions, and are, therefore, somewhat unreliable. To obtain positive information air testing is necessary. For instance, it is possible to take indicator cards showing full compression, correct fuel injection, correct opening and closing of inlet and exhaust valves, and yet, when the air test is carried out, it may be found that all the valves are leaking slightly, although not sufficiently to affect the card reading. While it may be argued that the leakage, therefore, is not worth considering, since it does not materially affect the running of the engine, and that when it does manifest itself to any extent it will be at once apparent from the indicator cards and operating symptoms, nevertheless it means that the true state of affairs is not known, and that by waiting until the symptoms develop may mean that when the part is opened up for overhaul the defect may be found to have extended to such an extent that a part renewal is necessary, thus adding to maintenance costs, whereas the expenditure could probably have been avoided.

It is scarcely likely that a ship will have a single run of sufficient duration to wear out any part of an engine, but before starting a trip of any length it is most advisable to prepare against contingencies, and this can best be done by testing all parts as stated.

## Watch-Keeping.

At the outset it may be said that watch-keeping on a motorship is much easier than on a steamship, irrespective of size. Even with the largest present-day motor-ship installation, one engineer can comfortably superintend the running of all the plant in the engine room during normal operation at sea when once the vessel has cleared the coast. Of course, in the bigger installations it is customary to have at least two engineers on watch at a time, but usually only the senior engineer does actual watch-keeping, while the junior employs his time in overhauling auxiliary machinery and spare gear. By following such routine, "field-days" are eliminated, while the work of inspection and overhaul is kept up to date.

Before entering the engine room to go on watch, it is advisable to have a look at the funnel exhausts and to note if any of the engines are smoking. With the modern air-injection Diesel engine there is no excuse for a smoky exhaust, provided the load is normal, with all parts in good condition and properly adjusted.

## Top Platform.

On reaching the top platform level the points to observe are:—

(*a*) Temperature of cylinder-head cooling-water discharge. In the event of abnormal temperature being met with the engineer should not rest content with merely readjusting it, but should try to locate the cause. When he comes to read the piston-cooling water-discharge temperatures, he should note how the figures compare with the cylinder-head readings and draw an inference.

(*b*) That all valves are apparently functioning properly. In the case of inlet and exhaust valves, attention should be paid to see that they seat properly, this being noted by the

*Abstract of paper read by Mr. A. J. Brown before the Institute of Marine Engineers, December 5, 1922.

vibration made as the valve closes, and can be checked by feeling the valve spring cap for shock. An alteration in the tappet clearance might tend to prop the valve open, but only to a small degree, so that the effect might scarcely be noticed and yet the valve seat would be damaged by scoring, due to the action of the high temperature gases. Inlet valves suffering from this defect would evidence it by the sound of spitting to be heard at the induction pipes, but exhaust valves give no indication by sound and cannot be checked for slight leakage until the engine is stopped. Should a slight leakage develop to greater magnitude, it will begin to record by an increased pyrometer reading.

Should a valve spring be broken the valve would show irregular movement, and this is easily checked by comparison with the movement of the other valves. In the vent of a spring completely breaking up (more common with high-speed engines) there would be no doubt as to what had gone wrong since the hammering noise would very soon draw attention to the defect.

Irregular movement can also be caused by the valve spindle tending to stick in its guide, but this defect is usually distinct, in that the valve shows more tendency to stay open as opposed to the shivering action caused by a broken spring. Of course, should the sticking develop to the extent of seizure, indication would be given either by the noise caused through the piston striking the open valve, in the case of an engine where the clearance space is small, or by the cylinder cutting out, due to loss of compression.

(*c*) That the fuel injection valve packing glands are tight, and that no escape of fuel or blast air is taking place from any of the joints. The roller clearance of these valves should also be observed to ensure that it is neither excessively small or great. This clearance can only be checked within fine limits by taking a set of indicator cards, since it is possible to be experiencing late injection without any external indication whatever. It is only when the opening point is excessively late that it will show in the exhaust, or when excessively early, by the noise caused through detonation in the cylinder.

(*d*) (Where the top-level camshaft is used.)

Camshaft journals and the like require no comment since they constitute everyday practice. Where the cams are concerned, the only one drawing attention is that for the fuel injection valve, since it almost invariably is made with an adjustable toe-piece, which, with the perversity of all things not intended to slacken back, may work loose.

Cam rollers want watching to ensure freedom of operation and apparently correct clearance being maintained.

In the case of a Beardmore-Tosi engine in which reversing is carried out by moving the rollers axially on their fulcrum pins, care must be taken to keep all the fulcrum pins clean and cam rollers particularly free.

Again, in the case of a Beardmore-Tosi engine which uses a director valve in conjunction with the combined inlet and exhaust valve, attention must be paid to the eccentrics operating the former, as indication is given of the condition of the director valves by observing the action of the eccentrics, much in the same way as the condition of the slide valve in a steam engine could be denoted by its operating eccentrics.

Then, the camshaft driving gears; these naturally would be inspected to see that the lubricating oil is reaching this its highest level.

## Middle Platform.

On passing to the middle platform the most important points are, in the case of a top-level camshaft engine, the bottom cylinder covers and piston-cooling gear glands. In the case of a bottom-level camshaft engine, such as a Burmeister and Wain, there must be added the camshaft, cam rollers, lay shaft and reversing gear, all parts needing same attention as in the case of top-level camshaft engine.

Each bottom cover should be inspected to see what amount of carbon deposit is on it, and the condition of this deposit should be noted. Under no circumstances should the deposit be allowed to accumulate to any appreciable extent, as there is always a danger of it working its way down through the piston-cooling gear glands and contaminating the water, finally causing undue wear of the gear including the piston-cooling pumps. Then there is also a likelihood of the deposit passing through the piston-rod glands and so contaminating the lubricating oil in the crankcase, finally manifesting itself in bearing trouble.

Yet another effect of too much deposit left lying on the bottom cylinder covers is that it may be drawn up with the pistons and cause scoring of the cylinder liners. This mainly happens through the compression effect caused by the piston on its downward stroke splashing the deposit asunder and causing bits to enter the space between the piston and liner walls.

When the bottom cylinder covers are being inspected it will be noted if there is any sound of gas escaping past the piston rings, or if there is a knock in the cylinder, only audible from this position.

It is important to note when piston-ring leakage first commences, as if all the symptoms at the start are noted and carefully analysed it may be possible to state decisively actually what caused the leakage. In this connection the deposit on the bottom cylinder covers should be examined to determine, if possible, the conditions of lubrication within the cylinder.

## Lubricating-Oil Consumption.

Lubricating-oil consumption is an important item in a motorship, and since the quantity used in the engine cylinders leaves no recoverable excess, naturally it is desirable to reduce the amount used to a minimum. When the bottom cylinder covers show a pool of "liquid" oil lying, obviously the quantity being used is in excess of the amount required, but, on the other hand, if the deposit is too dry in appearance and is in the form of hard carbon or coke, although to all other indications the lubrication is sufficient, it would be well to increase the amount given until the deposit shows just a trace of softness.

Other conditions governing this question include the temperature of piston-cooling discharge water, since, if this is allowed to rise abnormally at any time, the cylinder lubrication will be affected. The cylinder-head temperature bears on the question as well, as also does the exact nature of the combustion, these elements affecting the temperatures involved throughout the cycle and so affecting the cylinder lubrication to no small degree. Indeed, it is in this connection that conditions such as late injection are most pronounced in their effect, although it is a point usually ignored. After all, the lubrication of a cylinder should be varied according to the exact nature of combustion prevailing at the time instead of being left at a constant quantity, probably adjusted at a time when the engine was tuned up to concert pitch and under the best conditions.

In connection with piston-cooling gear glands, also viewed from the bottom cylinder cover, it is important that the first sign of leakage from them should be noted, as this also bears directly on the question of cylinder lubrication and piston-ring tightness. If piston-cooling water leakage develops at this point, it is probable that it will find its way on to the piston and cylinder walls, with the result that when the pistons are withdrawn for survey or examination it will be found that most of the rings are immovably stuck in the grooves. Water affects the piston rings and sets up corrosion, notwithstanding the presence of the oil and carbon with which the piston and rings are coated.

(*To be continued.*)

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SIROCCO ROLL OF HONOUR.—A memorial to 199 employees of the firm of Davidson & Co., Sirocco Engineering Works, who served in the war, was unveiled on December 13 at the works main entrance by Mrs. F. G. Maguire, wife of the managing director. It is situated opposite the tablet to Capt. J. S. Davidson, son of the founder, who fell at the assault on Thiepval in July, 1916.

# A NEW LIFEBOAT ENGINE.

**The Royal National Lifeboat Institution's Vertical Water-Cooled Six-Cylinder Type. General Description—Ignition Lubrication—Control—Ventilation—Starting—Cooling System.**

During the past few years the motor lifeboat has proved its worth time after time. The design and production of internal-combustion engines for such purposes is attended with many difficulties, and the satisfactory solution of many of these problems has been embodied in the latest engine of the Royal National Lifeboat Institution. The engine is interesting in that it was constructed by various firms—each firm taking a particular part or parts—under the supervision of Mr. Arthur F. Evans, the Institution's surveyor of machinery. The assembly and testing were carried out at the works of the Weyburn Engineering Company Limited, Elstead. The engine has been specially designed and built to meet the peculiar conditions of lifeboat service, and it is a very radical departure from the orthodox. A considerable amount of loss and delay was experienced in the production of the first engine owing to a fire which occurred at the Weyburn Engineering Company's works soon after its completion; whilst the first engine was being rebuilt, the Committee placed an order for seven other engines, the first of which was tried in December last.

## General Description.

The engine is of the vertical water-cooled totally-enclosed type, having six cylinders, 5½-in. bore by 7-in. stroke, and rated nominally at 80 b.h.p.

It is of monobloc construction, with detachable head, overhead valves, high- and low-tension ignition, governor, self-contained reverse gear, thrust block, and mechanical starting mechanism.

The pistons, which are 5½ in. in diameter, are the usual type found in modern automobile engines, although the bore and stroke is much greater than that usually met with in automobiles; they have a stroke of 7 in., and the speed of the engine is normally 800 r.p.m. when it gives the power above mentioned.

The main casting, or body, is a deep box totally enclosing the crankshaft, and provided towards the top with a horizontal partition which forms the water-jacket.

The actual cylinders are tubes passing through the water-jacket, and this jacket also carries the ports and pipes for the exhaust and the ingoing gases, these pipes and tubes, manifolds as they are called, being cast all in one with the body. This construction, in the form of plain tubes, or liners, has several advantages; a damaged cylinder can be cheaply and readily replaced while the absence of these actual cylinders facilitates the casting of the remainder of the body.

Each branch of the two manifolds leads upwards to the top of the body and appears as a hole, so that the top of the crank chamber shows ten of these holes, the open cylinders, and numerous holes which allow the water to circulate. The pistons, working up and down in the cylinders, come right up to the top and level with the surface.

On the top of the crank chamber, or body, is placed the cylinder head, one casting which covers the whole of the engine, and a view from underneath this head shows the six semi-spherical combustion chambers, the ten identical holes for the passage of the gases, as are found in the body, and an equal number of holes for the water connections.

There are two valves leading into the top of the combustion chambers, and these valves communicate with the ten curved ports or ducts which allow the gases to pass to and from the valves and the manifolds, and this arrangement makes it unnecessary for any large exhaust or inlet pipes on the detachable cylinder head, which also being free from water pipes can readily be detached and removed.

The camshaft which operates these valves is also carried on the head, as is the whole of the ignition arrangements.

It is only a question of time in every engine for the valves to require adjustment, cleaning, or grinding-in, for the pistons and combustion chambers to need the removal of carbon, and for the ignition gear to require adjustment and overhaul, and with a really good engine, these circumstances may occur time after time before it is necessary to pay any attention to the main bearings or pistons.

This special arrangement of readily detachable head allows the vulnerable parts to be removed in a very short time and for all this work of cleaning and adjustment to be carried out under favourable circumstances, and to allow everything to be tested for adjustment in a thorough manner before the head is replaced, as it will be seen that the camshaft can be operated by hand for this purpose.

## Crankshaft.

The engine is provided with a very stiff balanced crankshaft which is drilled through the centre and through the webs, thus forming a hollow crankshaft, while communicating holes are formed to provide for the flow of oil right through the shaft.

There are four bearings held in girders formed with the main body, and at the fore end a comparatively light flywheel, attached to the shaft by a flange, is carried in a housing cast with the body; there is an end plate which covers it in entirely. Where a capstan drive is required, this cover is arranged to carry the driving gear for the capstan, and consists of a cone clutch which fits into the flywheel and a screw gear arranged to force it in when required.

## Governing.

On the shaft at the forward or flywheel end is a bevel gear driving a vertical shaft which carries a special form of governor consisting of a number of large steel-bearing balls, carried in and rotating with a bowl-shaped casting and pressed down by a disc in such a manner that when the engine speed exceeds a certain amount the balls travel outwards and rise up to the sides of the bowl, and by so doing lift the disc and close the throttle.

Above the governor, and also housed in the main casting, is a dynamo which supplies the current for the ignition and lighting of the boat, but both the governor and the dynamo are completely housed.

At the other end of the crankshaft there is a bevel gear for driving the vertical shaft which, in turn, operates the camshaft on the cylinder heads, a "skew" gear for driving the water bilge and oil pumps, and a large "skew" gear, which is used entirely for starting, being geared when required to the small starting motor.

The after end of the crank chamber is provided with a facing which is bored to take the reverse gear housing, this gear being attached in detail to the shaft and the crank chamber, till finally the ball-bearing thrust block is bolted on, providing a self-contained and entirely enclosed engine and gear.

For access to the interior of the engine, three large inspection doors are arranged on each side of the crank chamber, and by means of these doors full access can be obtained to the lower part of the cylinders, the crankshaft, &c. If necessary, all the pistons can be withdrawn from the engine and any bearing

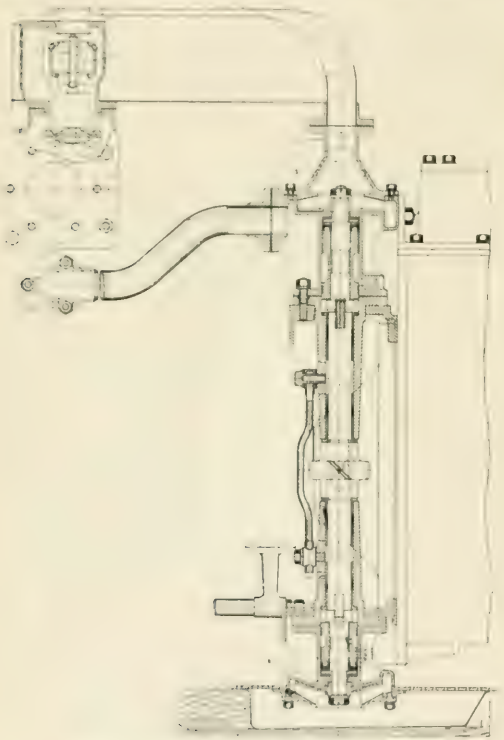
can be removed for examination by removing the doors and uncoupling the oil pipe that supplies these bearings.

On the reverse gear there are two large doors, which allow of the examination and adjustment of the clutches, though nothing has had to be sacrificed to allow of this accessibility.

### Ignition.

The ignition gear used with the engine consists of two entirely separate systems, high tension and low.

The main system is considered to be the low tension, and is a form of electrical ignition where a low voltage current is



**Air and Bilge Pumps with Drive Spindle and Thermostatic Valve.**

broken inside the cylinder by mechanical means operated from the outside. In order to amplify the spark so obtained and to conserve the current used, a powerful electro-magnet is placed in circuit, in effect an inductive or impedence coil, as it impedes the first flow of current and then induces a higher voltage when the circuit is broken. The coil collects and stores up energy in the form of magnetism, while the current is flowing and gives this out again when the circuit is broken.

The igniters consist of a pin insulated with mica and a small spindle with an arm at right angles inside and a trigger arm on the outside. A spring tends to hold the inside arm in contact with the insulated pin, both of which are provided with large tungsten points. Just before a spark is required, a cam operating through a striker first of all allows contact to be made and then separates the points with a blow on the trigger; the result is a very powerful spark which cannot readily be destroyed by damp, oil or dirt.

The igniter body also holds an ordinary high-tension plug which is supplied by a small non-trembler coil mounted on the cylinder head, one coil for each cylinder, and the low-tension or primary current for this coil is supplied by a conventional distributor, also in the cylinder-head cover, and driven by this igniter shaft.

This shaft is geared to the camshaft by helical gears, and the actual timing is arranged by sliding one of these gears along the other, this altering the relative position of the two shafts, and timing both high and low tension ignition.

The current for both of these ignitions can be supplied by the dynamo or by a battery, and in the usual way the battery is coupled to the dynamo and both ignitions are in use.

On the top of the cylinder head is a light aluminium cover which entirely prevents the escape of oil, or the access of water or damp, but this cover can readily be removed for examination.

### Lubrication.

The lubrication of the engine is on the forced system throughout; from a sump at the bottom of the crank chamber, holding over 10 gallons of oil, a powerful pump forces the oil, first of all through a filter and then to an oil cooler, where it is reduced to just above sea temperature. On reaching the engine the oil is carried by a large tube to each of the four main bearings and thence to the hollow crankshaft. This in turn feeds the connecting-rod bearings and splashes on to the cylinders. As the oilway in the crankshaft is continued right into the reverse-gear shaft, forced lubrication is supplied to all of the bearings in the reverse gear, which, in consequence, does not have to churn round in oil.

Separate pipes lead the oil to the bearings of the various pump drives and a branch pipe is carried inside the crank chamber right up into the head, where it feeds all the cam and igniter shaft bearings as well as the provision of forced drip feed to the actual cams.

At the end of the system is fitted a safety or relief valve which is set to blow at 5 lb., the surplus being directed on to the teeth of the camshaft drive. At this point a connection is made for a pressure gauge and just as the oil leaves the pump it passes a large safety valve set to blow at 30 lb. and another pressure gauge. The object of the large safety valve is to prevent any great increase of pressure when starting up on cold mornings, and the objective of a pump, perhaps three times the capacity necessary, is to provide an ample supply of oil when the bearings are worn and leaky.

### Fuel Feed.

There are two carburettors fitted, each one supplies three of the cylinders, and by this means the engine will run very well, and in a perfectly regular manner, if one carburettor is turned off. This arrangement has the advantage of enabling the boat to keep going if one of the carburettor jets should become choked.

### Control and Reverse.

The two throttles are interconnected and there is a separate butterfly throttle operated by the governor.

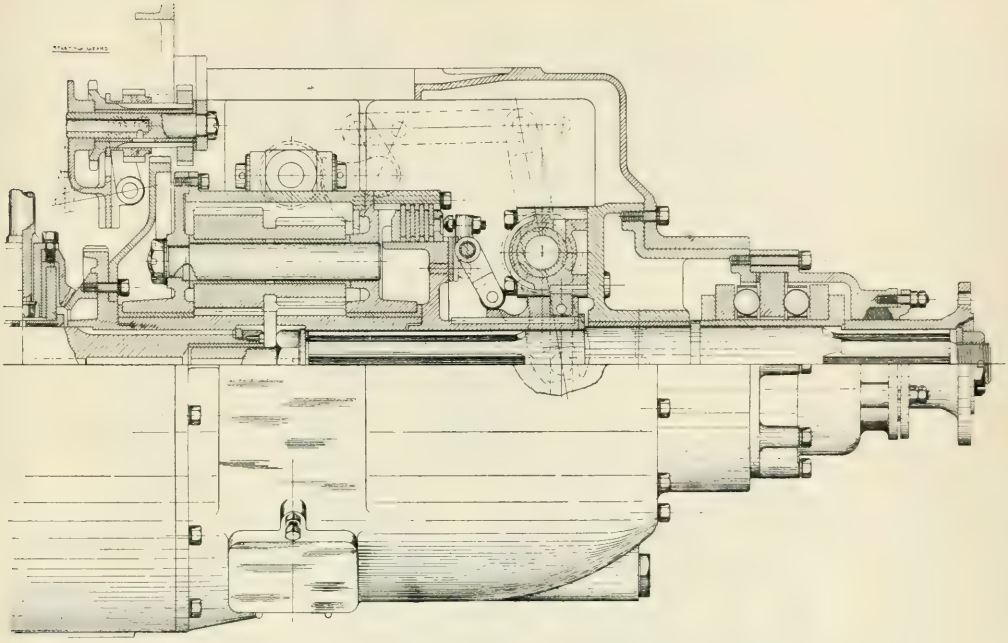
Connected with the reverse gear is a cam which operates the carburettor throttles quite independent of the hand throttle, which latter simply determines the amount of the maximum position.

When the reverse gear is in neutral, the actual throttle is closed to the amount determined by a handwheel, termed the minimum throttle, but when the gear is placed in the ahead or astern position, the actual throttle opens to just that amount required.

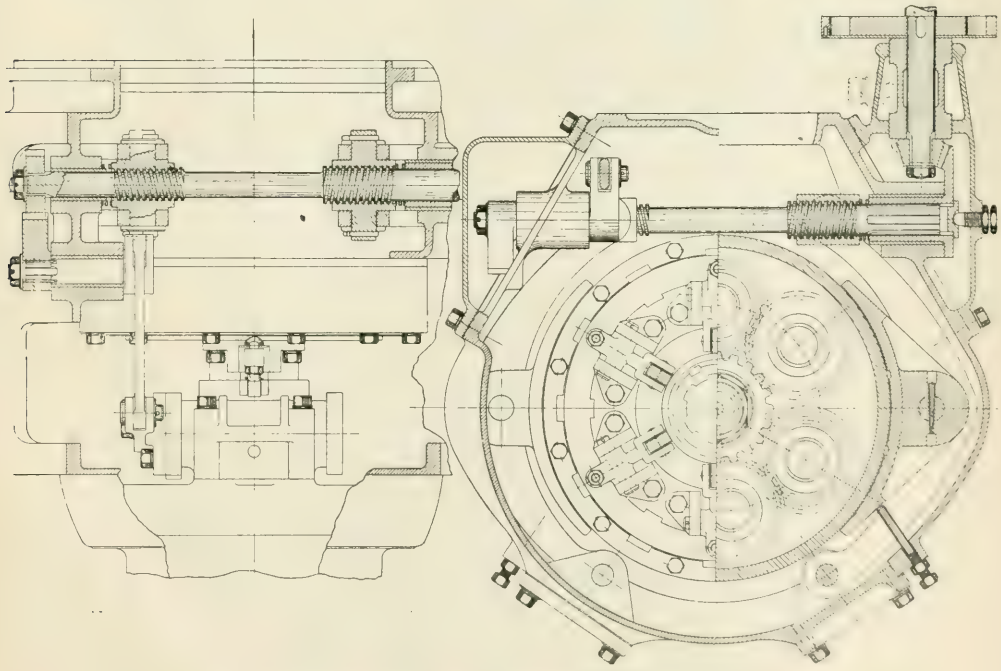
The result is that when the boat is being manœuvred in a constricted place, the engine can be made to turn slowly, while, when smart, definite operations are required, the handle throttle can be set for full opening.

Again, when starting up, when working the capstan, or the bilge pump, or when in a tight position in a heavy sea, the "neutral" speed of the engine can be increased.

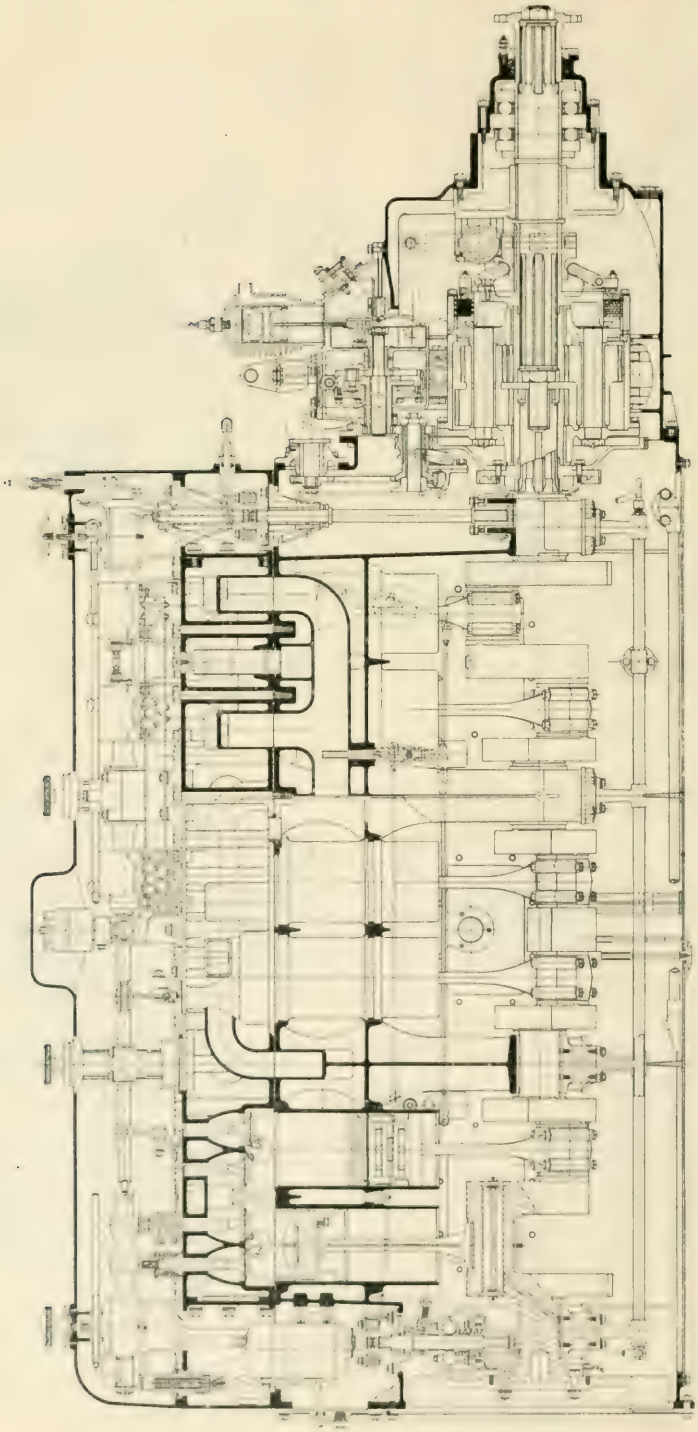
The objective of these apparent complications is to produce simplicity in the actual essential operations, as if the boat were called for service on a bad night, the driver would open



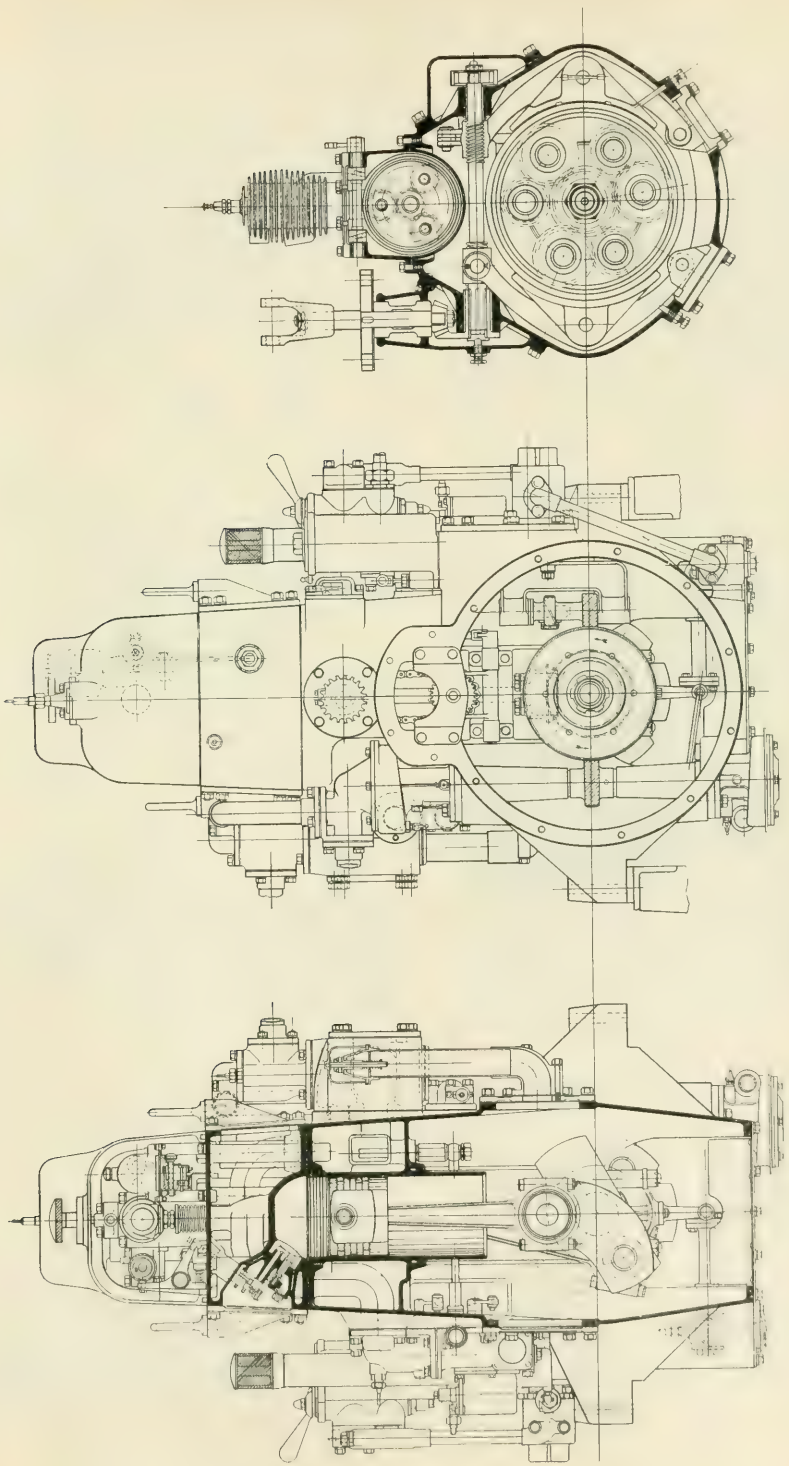
The Reverse Gear of the New Lifeboat Engine. Longitudinal Part-Sectional Elevation.



The New Engine Reverse Gear. Cross-Sectional Elevation and Plan.



R.N.L.I. Vertical Water-Cooled Six-Cylinder Engine. Longitudinal Sectional Elevation.



R.N.L.I. Vertical Water-Cooled Six-Cylinder Engine. Cross-Sectional Elevations.

up his maximum slightly, open the hand throttle to full before she was launched, and he would then only have to hang on to the control wheel and turn it to the left or right to execute all the manœuvres he might be called upon to perform.

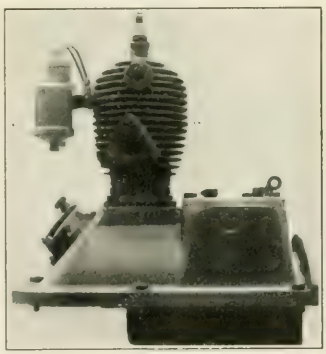
As everything is protected and lubricated, either by oil pressure to the bearings or by splash in the case of the gears, there are no moving parts visible on the engine with the exception of the after coupling which is connected to the propeller shaft. There is a packing gland on the main shaft, and all controls passing through to the engine are provided with glands, while the wires, two from the dynamo and one each for the two ignitions, pass through the engine by means of waterproof ebonite connectors.

### Engine Ventilation.

The vents to the crank chamber are carried up high and closed by watertight bells which can be dropped down immediately should it be necessary. The other vulnerable point, the air inlet, can be carried up as high as may be considered necessary; in fact, should it be so desired, by fitting suitable extensions to the inlet pipes the engine could be made submersible.

### Starting.

Large engines generally offer a serious problem with regard to starting, and in this case, since it was not desirable to depend upon batteries or compressed-air cylinders, a small two-cycle bicycle motor was specially made up with an epicyclic reduction gear and placed on the top of the reverse-gear housing.



Starting Motor.

There is also, it should be noted, a hand-starting gear fitted, and by this either the small engine can be cranked and started or the main engine can be turned over slowly.

To start the main engine the small motor is run, and then connected to the main engine through the agency of the differential gear brake. As the reduction is about 30 to 1, the starting motor revolves the main engine at about 60 r.p.m., which is fast enough to start up readily when everything is cold.

When the main engine is warm, however, even after standing all night, the hand gear alone is sufficient for starting.

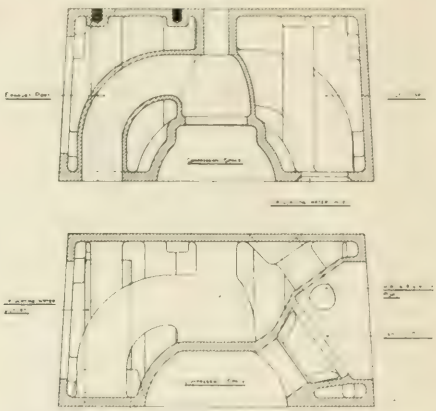
### Water Cooling.

The water circulation system consists of a powerful turbine pump which delivers water to the main jacket of the engine. From here it passes upwards through a number of ports to the water-jacketed head, and then by a downtake pipe to the delivery, which is located in the main jacket.

From this point it is led to a thermostatic valve, a piece of apparatus worked by the temperature of the outgoing water in such a manner that when the engine is quite cold, for instance, when starting up, the thermostatic valve returns all the water to the suction of the pump. This water then simply circulates through the engine till the designed temperature of 140 F. is reached, when the valve begins to open the port that leads to the sea and closes the port that leads to the suction of the pump.

This allows some of the hot water to escape and cold water to enter the system, and only just sufficient water is allowed in to keep the temperature between the limits of 140 degs. to 160 degs., and whether the engine is running quite light on a cold day, or at full power on a warm summer's day with the sea water at 65° F., the temperature automatically remains constant. The actual agent for effecting this is a multiple diaphragm tube made of copper filled with ether, with definite stop positions. This ether expands in such a manner that the tube starts extending at 140° F., and at 160° F. it has increased its length by $\frac{3}{8}$ in., and it is so robust that it will sustain 40 lb. or 50 lb., which is more than ample to move the small balanced valve that it has to actuate.

The pump is mounted on the top of the permanently-housed spindle*, and at the bottom of this spindle is another pump placed as low as possible below the engine, which acts as an automatic bilge pump as it starts operating as soon as the water in the bilge rises far enough to cover the blades.



Sections through Cylinder Tops showing Ports and Valve Seating.

### Dimensions, &c.

The weight of the engine is 37 cwt. complete with reverse gear, pumps, thrust and all ignition details, and, of course, inclusive of the starting engine. Its normal speed is 800 r.p.m.; at this speed it develops about 90-h.p., and when undergoing its tests it was found to run so smoothly that a coin would remain on the edge of the cylinder cover.

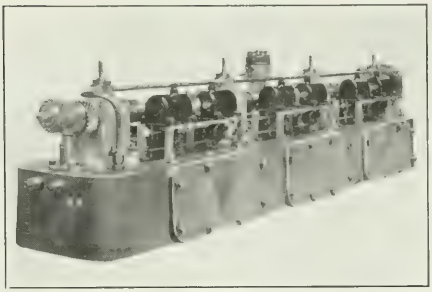
The overall length is 8 ft. 9 in. from the extreme forward end to the coupling face. The height above the shaft line is 3 ft. 3 in., and the depth below is 12 in., while the width overall may be taken as 2 ft. $4\frac{1}{2}$ in., this being the width over bearers.

The illustrations on page 28 show the engine with the top cover removed; the small plates on page 27 depict several interesting details of construction.

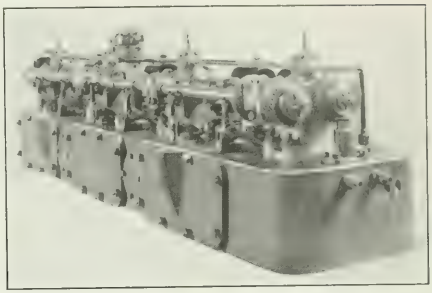
NEW APPRENTICES' INSTITUTE. Sir James Mart. Bart., Chairman of J. L. Thompson & Sons Limited, Sunderland, recently performed the opening ceremony in connection with an apprentices' institute which the firm has established in Fulwell Road, Sunderland. Two other companies with which Sir James is associated have provided similar recreative facilities for apprentices, the object being to put them into good company and make good men of them.

* This "permanently housed spindle" is one which remains in position when the pump is detached at any time for packing of glands, &c., as it is preferable to allow those parts which are not likely to require attention to remain permanently in their place when vulnerable parts are disturbed.

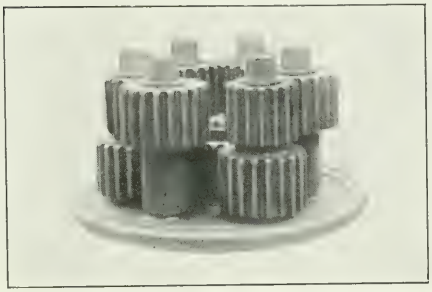
## SOME WORKING PARTS OF THE NEW LIFEBOAT ENGINE.



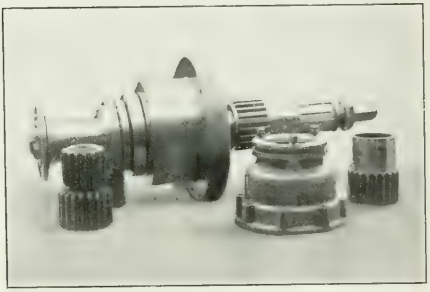
Cylinder Head, Port Side.



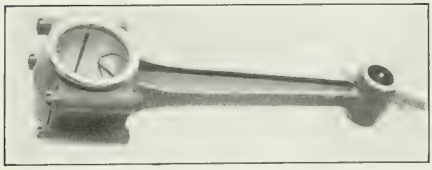
Cylinder Head, Starboard Side.



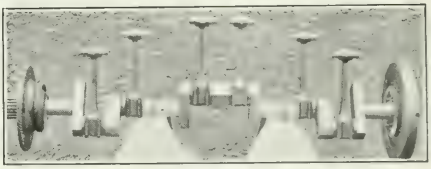
Reverse Gear Differential Assembly.



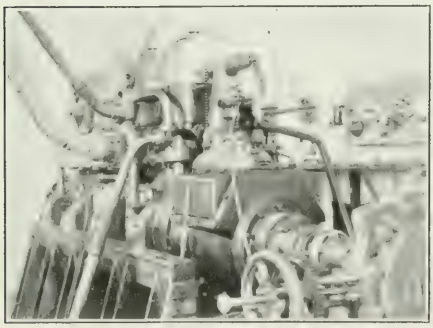
Thrust Block and Gears.



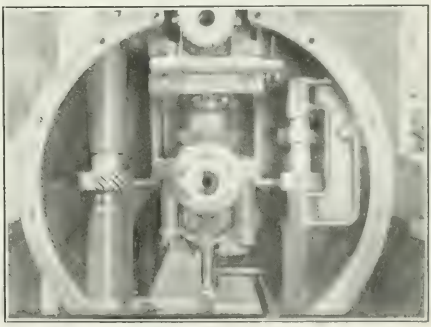
Connecting Rod.



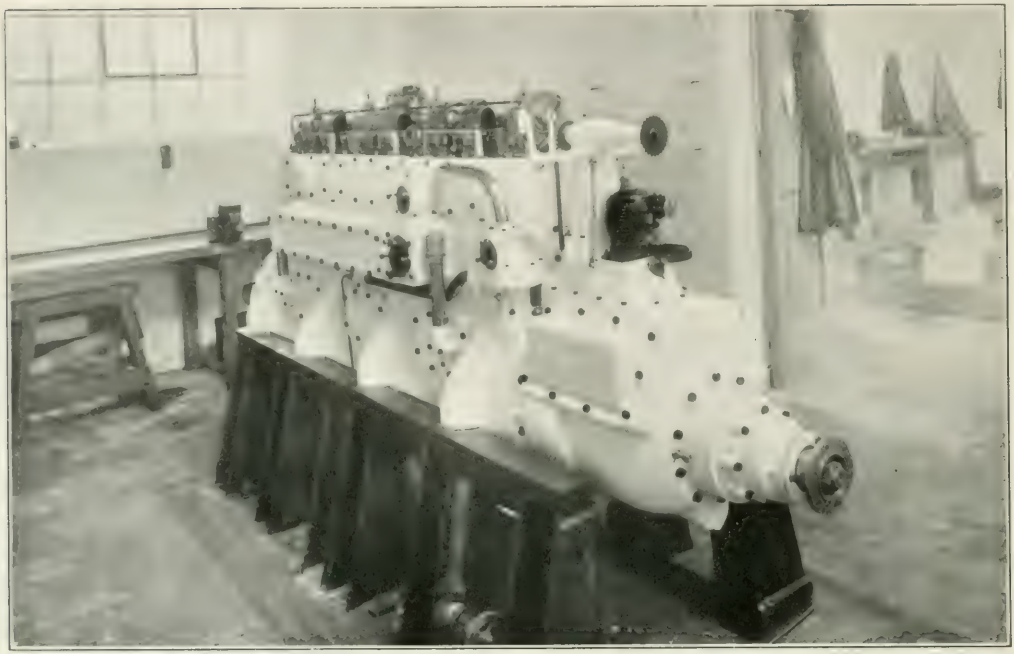
Crank Shaft.



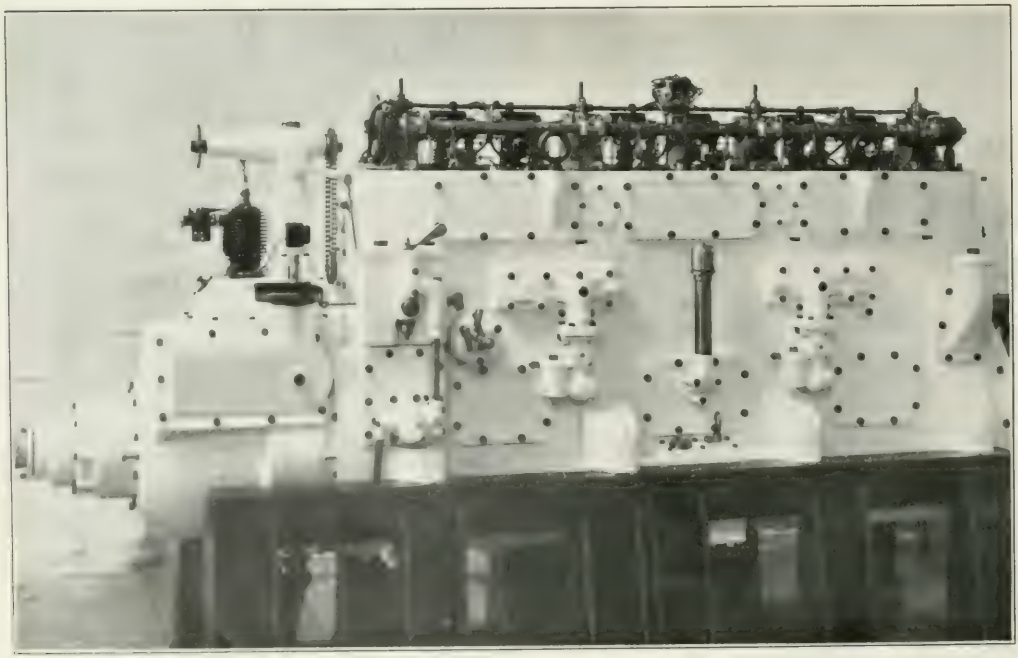
Engine on Test Bed.



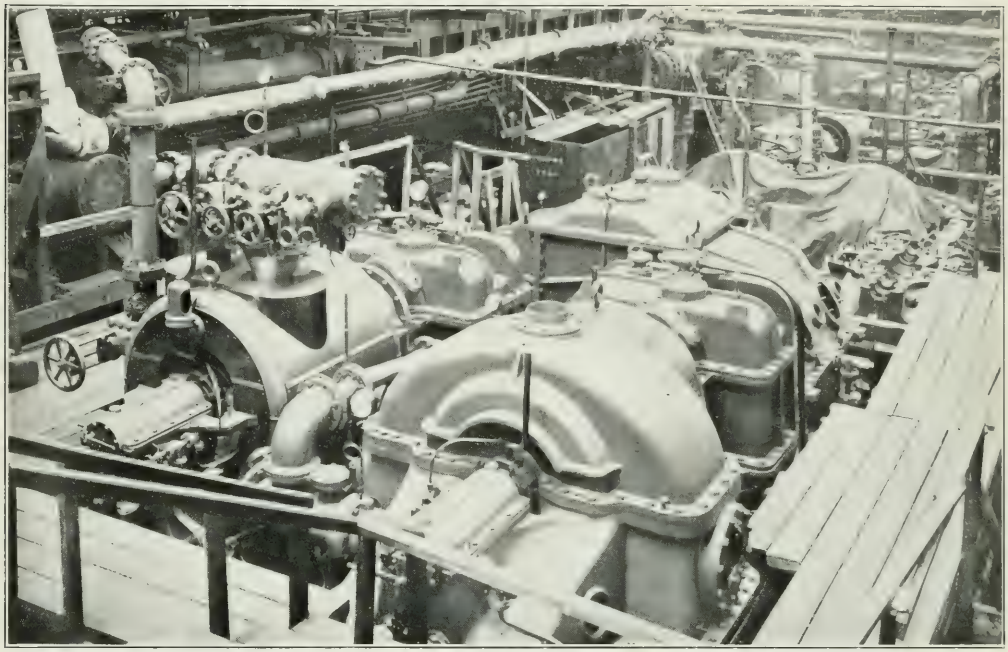
Aft End of Crank Chamber, showing Gears.



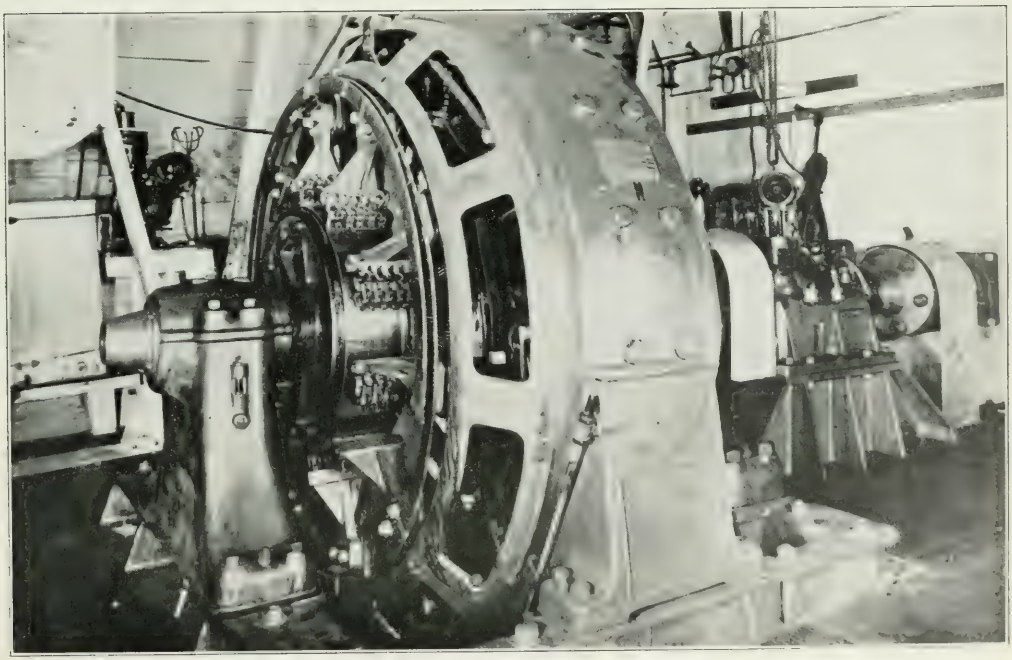
The New Lifeboat Engine, Port Side View; Cover Removed.



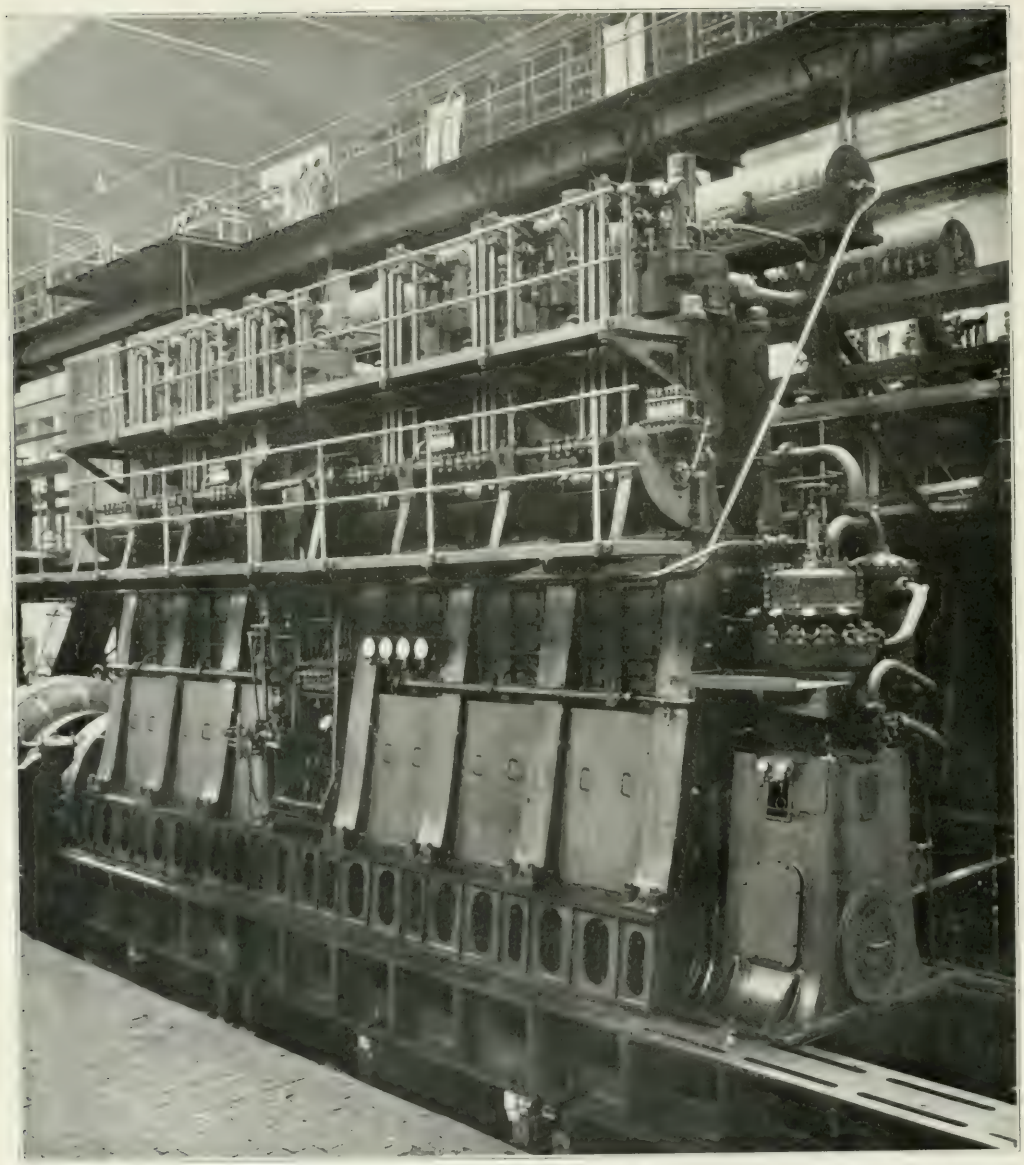
A Starboard Side View of the Engine, showing the Starting-Up Motor.



**Turbine and Gearing for SS. "British Commander," Erected on Test Plate at the Works of the Metropolitan-Vickers Electrical Co. Ltd.** (*See page* 14.)



**One of the Two 750-H.P. Direct-Current Main Propelling Motors for the New Diesel Electric Ferryboat "Golden Gate."** (*See page* 16.)



Main Diesel Engines, of the Burmeister and Wain Type, of the Motorship "Arizona." (See page 14.)

# NEGATIVE WAKE.

**Investigation into Phenomenon—Its Range and Limits.**

Both tests of models and analyses of carefully conducted ship trials not infrequently indicate that, in the case of torpedo craft run at speeds approaching their maximum, the wake is actually negative in value, and not, as in the case of practically all other vessels, of a positive nature. That is to say, in the expression for wake factor as originally given by Mr. R. E. Froude, viz., $\frac{V-V_1}{V_1}$, the speed of advance of the screw through the water is actually greater than that of the speed of the ship. So unlikely does this seem to be at first glance that it is of some interest to explore the conditions under which such a phenomenon is at all possible. That it is a tangible measurable quantity was first indicated by Mr. Froude in his 1898 paper to

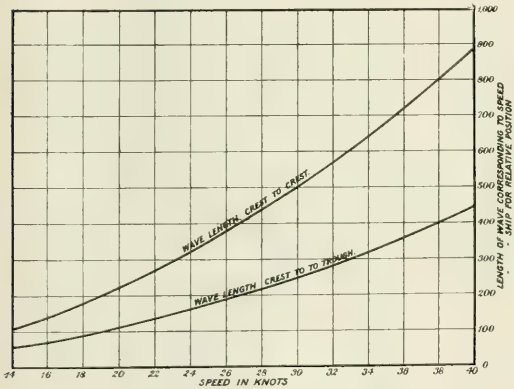

WAVE LENGTH CREST TO CREST.
WAVE LENGTH CREST TO TROUGH.
SPEED IN KNOTS
LENGTH OF WAVE CORRESPONDING TO SPEED
SHIP FOR RELATIVE POSITION

**Fig. 1.—Wave Lengths for Particular Speeds of Ship.**

the I.N.A. on "Inward and Outward Turning Screws." Thus, for the Laird and Palmer-built destroyers of the 27 and 30-knot types of that period, both of which were distinguished by very cut-away afterbodies and big propeller clearances, with very tapering waterlines aft, the wake factor, as determined by experiment in the Haslar tank, was stated to be between about $-0{\cdot}007$ to $-0{\cdot}015$ compared with a positive value of $0{\cdot}012$ to $0{\cdot}042$ in the case of the Thornycroft designs in which the very flat, and even partially concave, stern was very broad on the waterline. The propellers, in the latter designs, were completely covered by the hull and were therefore subject to a considerably greater extent to any dragging effect of the vessel's stern on the water than were the former, in which, in section, the propellers projected far beyond the sides of the ship, though it is curious to note that the prismatic coefficients of the afterbodies for the lowest negative and highest positive factors quoted above were identical ($0{\cdot}54$).

Although, in measuring the speed of advance in open in the tank at which the model screw gives the same thrust as it does in the disturbed water behind the model, and in subsequently deducing the wake factor, as is generally done in tank practice, it is convenient to consider the wake as being equivalent to a following current of uniform density and forward velocity, this, as is well known, is far from being the true case; and in arriving at a value by means of analysis instead of by tank trials, the figure thus found should be regarded more as a measure of the difference of condition under the stern rather than as a determination of the actual speed of advance of the screw. The extent, however, of the negative value of the wake as thus found for many torpedo craft, especially the United States destroyers of recent design with very long and fine afterbodies, is too marked to represent merely a difference in condition; there can be no doubt at all that the flow of water to the screw $V_1$ at full speed is definitely slightly faster than the actual speed of the vessel V, the fraction $\frac{V-V_1}{V_1}$ in several analyses being of the order of $-0{\cdot}025$ to $-0{\cdot}028$. This negative quantity, however, is only a passing phase, and the object of the following investigation is to trace the range and limits of its extent.

The difference between V and $V_1$—or wake, as usually defined—is due to several causes of varying magnitude and

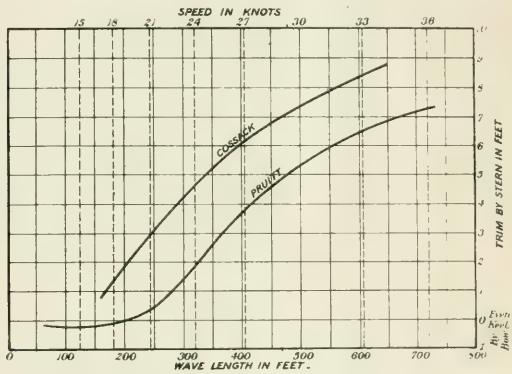



**Fig. 2.—Alterations of Trim for Various Speeds. H.M.S. "Cossack" and U.S.S. "Pruitt."**

is dependent on a number of conditions, but in principle it results from—

(*a*) The stream line flow of water round the stern;

(*b*) The frictional effect of the surface of the hull upon the water, and

(*c*) The dragging action of the vessel's stern on the water in the vicinity of the screw.

These three causes are all of a positive nature, their effect varying in intensity with obvious differences in condition of surface, shape of hull, position of screw, &c. Besides these, there is also—

(*d*) A wake due to the orbital motion of the particles of the transverse wave formed by the movement of the vessel.

Assuming the profile of this wave to be trochoidal, at the crest the direction of motion of the wave particles is forward; in the trough the direction is aft, so that if, as in destroyers which are run over a wide range of speed-length ratio, there happens to be a distinct wave at the stern at intermediate speeds, the wake will then be considerably augmented, while on the other hand if, as is generally the case at full speed, the stern is lying in the hollow of a wave, the wake is materially reduced or may even be negative, owing to the motion of the wave particles, depending upon whether the combined effect

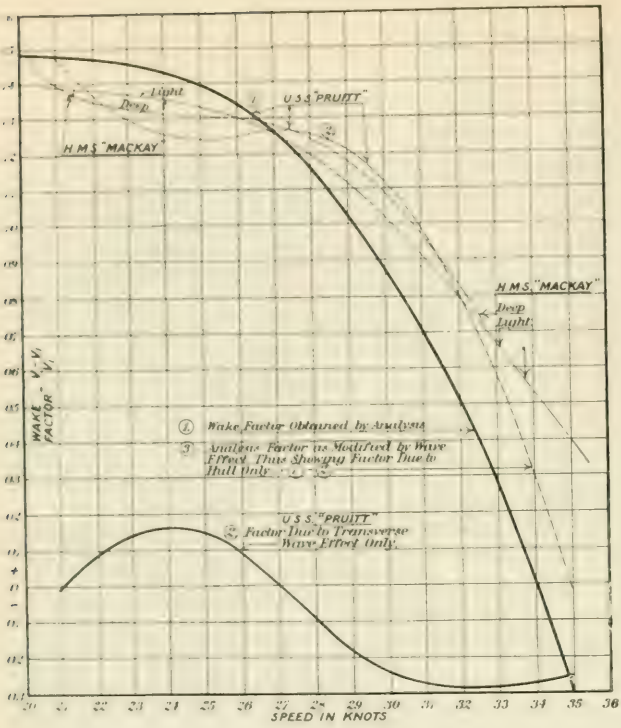



Fig. 3.—Wake Factor Curves "Mackay" and "Pruitt."

effects over the disc area which exerts the effect.

Confining attention mainly to the influence of wave effect on wake, for this is the only one of the four elements that can induce negative wake, in Fig. 1 will be found two curves, one showing the lengths of free repeating waves in deep water according to the expression connecting speed and length, viz., $V^2 = 1{\cdot}34L$, where V is in knots and L in feet from crest to crest, the other showing the half length from crest to trough. Although the wave-making length of a ship may be slightly greater than the ship's own length, the amount may be ignored in this case, and the position of the stern of a ship of any given length and speed in relation to the position of the stern wave can be read off as well. Thus at 33 knots a destroyer 300 ft. long will be seen to have a trough at the stern, and a 450-ft. cruiser at 28·5 knots will have a crest.

In order to estimate the possible value of the wave-created wake it is necessary to assume a trochoidal profile for the transverse wave, and also to know the height from crest to trough. Measured records of the latter are hardly to be found in any published data. They are often recorded photographically from another vessel, parallel indicating lines having previously been painted down the vessel's sides, or more simply by measuring from the edge of the deck to the water, and simultaneously recording the vessel's trim. It is possible to obtain a rough idea of the essential ratio of $\frac{\text{length}}{\text{height}}$ from measurements of the trim, and in Fig. 2 are shown the recorded

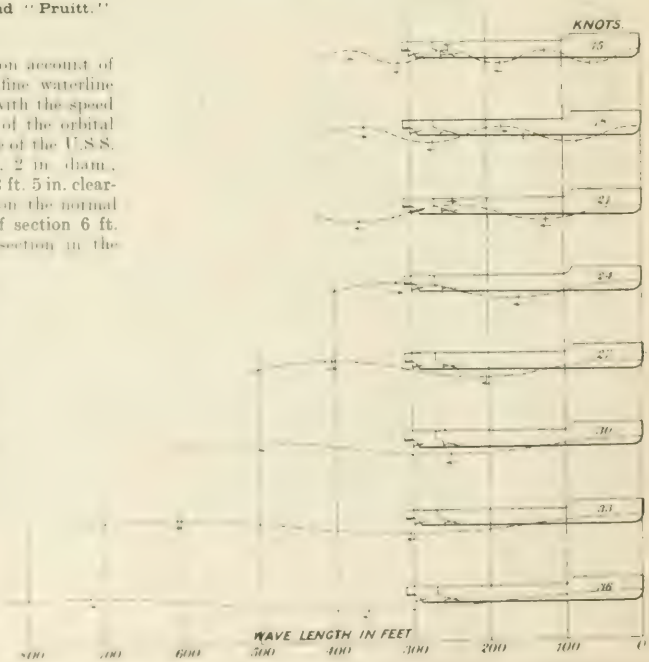



Fig. 4.—"Cossack" and "Pruitt," showing Wave Profile at Various Speeds.

[illegible] and (b) to be paramount, or whether, on account of their small magnitude and the fact that a very fine waterline and curve of areas aft will interfere but little with the speed of the wave particles, the sternward influence of the orbital motion of these particles is greatest. In the case of the U.S.S. *Pruitt*, for example, with two propellers 9 ft. 2 in. diam., with 6 ft. 6 in. clearance between the tips, and 2 ft. 5 in. clearance from the hull, the breadth of the hull on the normal L.W.L. was only 7 ft. 6 in. and the depth of section 6 ft. The ratio of total disc area to area of hull section in the plane of the propellers was nearly 5·4 to 1·0. Such a condition is, of course, extreme. In the case of a large vessel with twin screws and Diesel engines, the ratio of areas may easily be 1·0 to 2·0 or even more in the opposite direction. The former proportions readily indicate how it may arise that the wave element may have practically uninterrupted play. The total effect of these four influences as regards the ultimate extent to which the [illegible] depends mainly on—

(*a*) The position of the propeller in relation to the hull, whether fore and aft, transversely or vertically, and

(*b*) The diameter of the propeller.

Proportions of the screw such as pitch, area, number of blades, &c., seem to [illegible] exert relatively little influence; it is the variation of intensity of the hull and wave

alterations to trim at various speeds for H.M.S. *Cossack* and the U.S.S. *Pruitt*. The following were the dimensions of the two vessels :—

| | H.M.S. *Cossack*.[1] | U.S.S. *Pruitt*. |
|---|---|---|
| Length beam draught. | 270′ 26′ 8′ 2″ | 310′ × {30′ 11½″ mld. / 30′ 9″ l.w.l.} ∨ 9·3″ |
| Displacement | 836 | 1210 |
| Coefficients— | | |
| Block | 0·510 | 0·472 |
| Mid section | 0·810 | 0·754 |
| Prismatic | 0·630 | 0·627 |
| L.W.L. | 0·715 | 0·680 |
| Tons per inch immersion | 12·35 | 15·5 |

1. *See* Sir Phillip Watt's paper, I.N.A., 1909.
2. *See* Mr. J. Burkhardt's paper, *Jour. Am. Soc. Nav. Eng.*, February, 1921.

The wave lengths corresponding to the speed, or $L = \frac{V^2}{1 \cdot 8}$, divided by the trim, give an *approximate* guide to the value of $\frac{\text{length}}{\text{height}}$ of wave, and the following ratios are thus obtainable for the two ships :

TABLE I.

| Speed in knots. | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
|---|---|---|---|---|---|---|---|
| Length of wave trim ÷ | | | | | | | |
| *Cossack* | 135 | 82·0 | 69·6 | 67·5 | 68·2 | 72·0 | [80] |
| *Pruitt* | | .. | 168·3 | 103·9 | 94·0 | 93·2 | 99·5 |

It must be clearly understood that this assumption is only made in view of the lack of more exact measurement, but, for the moment, it serves our purpose.

In order to explore the possible extent of the influence of this transverse wave only upon the wake, Fig. 4 has been prepared. This shows the lengths of *Cossack* and *Pruitt* with the wave crest and trough positions to scale in order to locate the position of the latter in relation to the propeller position in the two ships. On account of the small scale it has been necessary to exaggerate the wave height and to use a constant dimension for it for purposes of illustration. From the construction of the trochoidal wave profile we can calculate the rolling speed at the periphery of the wave circle, and hence, at crest and trough, the absolute forward and sternward velocity of the wave particles relatively to the ship. The actual speed is equal to $\frac{\pi \times \text{speed of ship}}{\frac{\text{wave height}}{\text{wave length}}}$. Then, for various values of $\frac{L}{H}$, we can estimate the actual speed of the screw through the water and the wake factor.*

TABLE II.

For V = 33 knots. L = 605 ft.

| Ratio $\frac{L}{H}$ .. | ... | $\frac{1}{80}$ | $\frac{1}{90}$ | $\frac{1}{80}$ | $\frac{1}{90}$ | $\frac{1}{100}$ | $\frac{1}{110}$ | $\frac{1}{120}$ |
|---|---|---|---|---|---|---|---|---|
| H in feet | 12·1 | 10·1 | 8·64 | 7·56 | 6·72 | 6·05 | 5·5 | 5·04 |
| Speed of wave-surface knots | 2·074 | 1·728 | 1·479 | 1·295 | 1·152 | 1·037 | 0·942 | 0·864 |
| Possible negative wake factor .... | 0·0592 | 0·0498 | 0·0429 | 0·0378 | 0·0388 | 0·0304 | 0·0278 | 0·0255 |
| Possible positive wake factor | 0·065 | 0·0552 | 0·0479 | 0·0409 | 0·0362 | 0·0324 | 0·0294 | 0·0269 |

* These values, of course, hold good at all speeds for the same ratios of $\frac{L}{H}$.

These wake factors can only be obtained provided that—

(*a*) Crest or trough are in the immediate vicinity of the screw. (*See* Fig. 4, 21 knots for *Cossack*, or 33 knots for *Pruitt*), and

(*b*) There is no wake influence due to causes (*a*), (*b*), (*c*) quoted above.

From Fig. 4 it is possible to estimate fairly closely the extent to which these possible wake factors are modified in the case of these two ships. To do this, however, means that allowance must be made for the forward or sternward component of the surface velocity of the wave, as modified by the position of the crests and troughs, in those cases when they do not coincide exactly with the screw position. Thus, for *Pruitt* at 27 knots, or *Cossack* about 24·5 knots, the effect is neutral. Allowing for this variation in wave position, the actual wave effect figures for the two ships, corresponding to the $\frac{L}{H}$ values in Table II, become as Table III below.

These results are shown in Fig. 5, but if plotted to a speed-length ratio base, as given in Fig. 6, a remarkable resemblance between the two sets is found, any variation only being marked at low speeds, at which, as shown in Fig. 2, the trim of the *Cossack* greatly exceeded that of *Pruitt*.

Now let us turn to Fig. 3. Here are plotted the curves of wake factors obtained by analysis for the *Pruitt* and H.M.S. *Mackay*, the only two torpedo craft of which full thrust meter records are available. For *Pruitt*, the estimated factor due to wave action only is added. Unfortunately, there is neither adequate data to enable us to plot *Cossack's* wake factor, nor any information regarding *Mackay's* trim. Obviously, the net wake factor, being the creation of the sum of causes

TABLE III.

| Speed in knots. | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
|---|---|---|---|---|---|---|---|
| *Cossack*.. | −0·0239 | +0·0378 | +0·0114 | −0·023 | −0·0305 | −0·0275 | |
| *Pruitt* | | 0 | +0·0168 | 0 | −0·0248 | −0·0284 | −0·0255 |

(*a*), (*b*), (*c*) and (*d*), can be considered as due to hull effect and wave effect, so that the gross effect due to hull only can be indicated by a curve (3) obtained by combining curves (1) and (2). This seems to show clearly that down to 27 knots, or $\frac{V}{\sqrt{L}} = 1 \cdot 53$, the negative wave influence has materially reduced the effect of the hull only, but that below this point, for the range where the ordinary stern wake is augmented by the superposition of the crest of the free repeating bow transverse wave (that is, at about 21 knots for *Cossack* and 24 knots for *Pruitt*), the hull effect is temporarily reduced until the positive wave effect again vanishes (at 21 knots for *Pruitt*). It might be doubted at first whether the gross hull effect should take this form of curve (3), but on consideration of the relative velocities of hull and wake in the vicinity of the screw over the range of speed indicated, it would seem reasonable to believe that it does do so.

The wake factor curves for *Mackay* are based on the writer's own analysis and differ slightly from those published by Mr. Frodsham Holt, owing to differences in the analysis pitch and "B" factor taken for the propellers. Mr. Holt's figure shows a lower wake factor for *Pruitt* than for *Mackay* at all speeds, and for the latter vessel a bigger wake factor on the deep than on the light load trial throughout. The hull sections at the screws for the respective vessels are similar to those shown

in Fig. 7, and these two shapes also resemble closely those of the Laird and Thornycroft destroyers referred to above. It is obvious that wave effect must influence the former to a considerably greater extent than the flat stern of the latter will permit, and the result is that, in cases such as B, the positive causes of wake, (*a*), (*b*) and (*c*) above, are paramount at full speed, and entirely eradicate the negative wave effect. As would be expected from the greater immersion on *Mackay's* deep trial, the wake factor exceeds that at

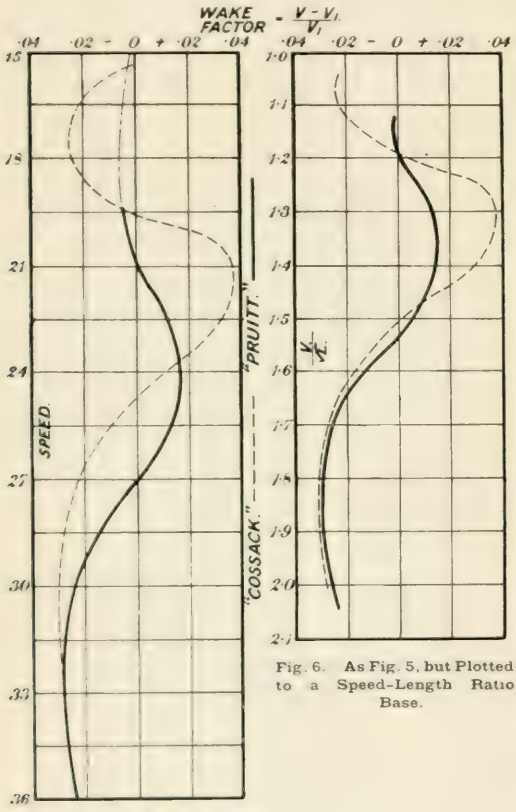



Fig. 6. As Fig. 5, but Plotted to a Speed-Length Ratio Base.

Fig. 5. Wave Effect Figures Corresponding to $\frac{L}{H}$ values from Table II.

light load at the higher speeds; when, however, the direction of the wave particles change during the 22-26-knot phase, the conditions are reversed. *Pruitt* is again affected to a greater extent but in the opposite direction, and what wave influence is exerted in the case of *Mackay* must necessarily be slightly more at light load than at deep. Hence the somewhat higher factor at light load, but still one that does not quite equal that of *Pruitt* in spite of the preponderance of the positive causes [illegible] particularly the two latter ones.

It is true that the foregoing arguments introduce a certain degree of controversial matter, and that one or two arguments need justification. The object of the investigation was to ascertain the approximate limits of negative wake, and with the ratio of wave length to height in large torpedo craft at full speed it has been shown—and measured records corroborate it—that where values of about 90 to 110·1 prevail, the maximum negative values run from about −0·034 to −0·028 *when no hull effect at all intervenes*. At full speed *Pruitt's* value appears to have been reduced from a possible figure of −0·03 to −0·025. Extreme accuracy is impossible in these cases: we made a debateable assumption for $\frac{L}{H}$ in using the figure for trim, though this produced (see Fig. 5) noteworthy similar values for two entirely different hulls; we are striving for a close approximation to the truth from somewhat inadequate data. In view of the shape of *Pruitt's* curve of gross hull effect (No. 3 in Fig. 3) it might seem as if the negative values in curve 2 were exaggerated. Pilot tube tests in the Washington tank on a 20-ft. model showed a variation over the screw disc at a speed corresponding to 30 knots of from +1·6 per cent. of the vessel's speed at a point nearest to the hull to −1·6 per cent. at the propeller centre, whereas our calculated mean value is −0·0248. The unknown value of the analysis pitch factor inevitably intervenes in the determination of wake factors by analysis, and in selecting the compromise to be made between the two, it is, as Mr. Burkhardt very aptly expressed it to the writer, "almost anybody's guess." What is, perhaps, the most remarkable feature of all the analyses made, both in the case of *Mackay* and *Pruitt*, is the rapid increase in wake factor for a very small absolute drop in speed below the maximum. Next we find an unexpectedly high value of wake factor at the lower speeds. Some of this is undoubtedly due to the assumption of a constant analysis pitch factor instead of accepting a variable (and increasing) value as the speed decreases; some may be due to the fact that the dragging action of these long, fine hulls at lower speeds has hitherto been underestimated. It seems, however, indisputable that a range of wake factor exceeding an absolute value of 0·04, due to wave action only, was experienced in *Pruitt*, while, as regards the three separate trials, the general results of the analyses would appear to be particularly consistent.

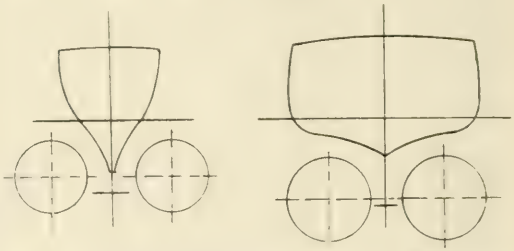


Fig. 7.—"Pruitt" and "Mackay"; Hull Sections in way of Screws.

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DIESEL FUEL VALVE.—At a meeting of the Diesel Engine Users' Association recently, Mr. G. E. Windeler's paper on "Care and Maintenance of Diesel Engines" was discussed. Mr. P. H. Smith expressed the opinion that the engineer who thoroughly understood the fuel valve of a Diesel engine had little else to learn about Diesel engines, for the rest of the engine was similar to most other internal-combustion engines. He considered that in all fuel valves it was essential that the needle be guided at its point, and that it should have a fully ground-in face and not a ridge at the top or bottom of its cone. It was only within the last few years that it had been definitely established that a defective needle, or seating, produced some of the most serious breakdowns. If the needle did not completely and absolutely close, destructive distillation would take place in the cylinder, resulting in a tar-deposit on the cylinder walls which would cause piston rings to stick and possibly a piston seizure.

# NOTES FROM THE FOREIGN PRESS.

**Specially abstracted for "The Marine Engineer and Naval Architect."**

### The Resistance and Propulsion of Ships.

In this article the present position of the subject of the powering of ships is outlined. The growth of the experiment tank instituted by Froude and the passing into disfavour of empirical formulæ are touched upon. The form coefficients and parameters by which the phenomena of resistance are principally interpolated are discussed, after which the Froude law of comparison is dealt with. The author comments upon the tendency to credit Newton with the primary enunciation of this law, and points out that in none of Newton's works does a *per se* enunciation of the law of comparison of fluid motion appear. The credit of the earliest treatment of the subject as far as Germany is concerned is given to Helmholz, who in 1873 dealt with the subject before the Berlin Academy of Science. Next, the subject of frictional resistance is taken up and an approximate law of comparison (following Taylor) is set up. The importance of this law is brought out by examples taken from the trial data of German naval vessels. (To be continued.)—*Geheimrat Rudloff, Schiffbau*, November 15, 1922, p. 92 ; 4½ pp. ; 1 ff.

### The Sea Transport of Locomotives.

In the spring of 1921 Russia ordered from Germany some 700 locomotives, their ultimate transport to Petrograd having to be effected by sea from Hamburg. One hundred locomotives per month had to be conveyed, and their actual carriage formed an interesting problem. The urgency of their delivery ruled out the construction of special ships, and finally a number of vessels were chartered and after extensive internal preparation effected the transport quite safely. These vessels were the m.s. *Odin* and the steamers *Kaprino, Tynemouth, Chalister, Maskinonge* and the *Mendip Range*. The necessary structural alterations involved the lengthening of hatches, the erection of rail platforms on deck and on the tank top and the construction of necessary securing devices. In several cases watertight bulkheads had to be removed, the necessary transverse strength being maintained by leaving sufficient of a web construction at the sides of the ship. The whole of the conversion work was carried out by the Deutsche Werft and Joh. C. Tecklenborg. This article contains a mass of useful detail which should prove of considerable assistance to shipbuilders and repairers likely to undertake work of a similar nature.—*O. Bensel and Dr. Foerster, Werft Reederei Hafen*, November 22, 1922, p. 732 ; 12 pp. ; 41 ff.

### The Contra Propeller.

This article forms a very comprehensive treatment of the development, recent experience with, and technique of the contra propeller. The pre-war development was restricted to the early work of Dr. Wagner, who in 1912 published the results of trials on a German torpedo boat in which, at a speed of 28 knots, a saving of 12 per cent. in power was effected by the introduction of the contra propellers. The war interrupted the development, but since the war considerable progress has been made. Savings of power ranging from 10 to 20 per cent. have been repeatedly proved on service, and many complete details of actual trial data are given. In the *Stecknitz*, belonging to the Norddeutscher Lloyd, carefully carried out trials were made in the spring of 1920. First the vessel was tried with its old propeller; next, as this propeller was inefficient, a new propeller was fitted with a resultant saving of power of 7 to 8 per cent. Then the guide blades were attached and the result was a further saving of 15 per cent. Trials on the Brevik mile of the Norwegian vessel *Hovmøy* of 1,300 tons d.w., carried out under the technical superintendence of Professor Morch of Trondhjem University, showed the astonishing saving of 17·2 per cent. The Norwegian steamer *Granit*, of 1,000 tons d.w., showed a saving of 15 to 16 per cent. The case of the Norwegian passenger vessel *Brevik*, which owing to its age could not maintain its speed on service is interesting, for when fitted with the contra propeller the necessary speed was easily obtained. The Norwegian vessel *Neptun*, of 1,200 tons d.w., first had its old propeller removed and a new one installed with a resulting improvement of 6 to 8 per cent. The fitting of the guide blades resulted in a further saving of 11·6 per cent. at 11 knots and 16 per cent. at 12 knots. In the Norwegian vessels *Ottar* and *Frednes*, which were fitted with guide blades, no definite comparative trials were run, but in the case of the *Frednes* a saving of coal consumption of 10·7 per cent. has been made. In the ss. *Eikland*, of 2,040 tons d.w., a saving of 11·5 per cent. was obtained. The Hamburg Amerika liner vessel *Andalusia* showed a saving of 20 per cent. over the performances of its sister ships *Alesia* and *Arabia*. Altogether eight applications of the propeller have been fitted. Fourteen vessels up to a deadweight of 8,000 tons are yet to be fitted. An objection which at first was thought to be a serious one—that of the breakage of the blades—has not proved so on service. Only in one case, that of the *Andalusia*, has a blade been broken. In this case one of the blades was severed at about its half length, but strangely enough the saving in power was not adversely affected. This accident lead to experiments being carried out on the problem at the Hamburg Experiment Tank, the results of which showed that the diameter of the guide blades could be considerably less than that of the main propeller without destroying its beneficial influence. This reduction of diameter will considerably increase the safety and strength of the guide blades. An interesting feature of the contra propeller is that it increases the manœuvring qualities of the vessel to which it is attached. In the case of the *Neptun* the tactical diameter was reduced to five-eighths of its former value. Detail plans of actual contra propellers are given with the articles, and their routine construction is carefully gone into. The final portion of the article is devoted to the theory of the contra propeller, and the treatment, based upon the latest and most reliable theories, shows that the savings which have been realised in practice are of the order which theoretical investigation leads one to expect.—*W. Kucharski, Werft Reederei Hafen*, November 22, 1922, p. 715 ; 18 pp. ; 18 ff.

### Twin-Screw Motorships "Rheinland" and "Ermland."

These two vessels, built by Blohm & Voss for the Hamburg Amerika Line's eastern trade, are practically sister ships to the *Havelland* and *Münsterland*. These latter it will be remembered were fitted with M.A.N. submarine Diesels and had a reduction gearing fitted which effected a reduction between the engine and propeller revolutions of 2·7. The newer ships *Rheinland* and *Ermland* are fitted with directly-driven M.A.N. four-stroke Diesel engines, which run at 95 r.p.m. with a brake horse-power of 1,750 and an indicated horse-power of 2,200. The powering and form of the ship was decided upon from experiments carried out by the Hamburg Tank, and good agreement between tank and trial performance was obtained. The vessels have the following principal particulars : length, b.p. 136·622 ; beam ex. 17·678 m. ; depth mld., 9·004 m. ; draft, 7·643 m. ; G.R.T., 6,526 ; deadweight, 9,910 ; speed (service), 11 knots ; service indicated horse-power, 4,000 ; capacity-deadweight ratio, 60·5 cub. ft. per ton. Permanent bunkers are provided containing 1,376 tons of oil, the daily consumption for the *Rheinland* at 10·8 knots being 11·9 tons of oil, and for the *Ermland* at 13·4 knots, 13·52 tons. These consumptions refer to the main engine alone. With all auxiliaries the consumption of the *Ermland* amounts to 16·36 tons. The main engines are very fully described and illustrated. Each has cylinders of 720 mm. diam. with a stroke of 1,300 mm. In determining the size of tunnel shaft (engines amidships) it was found that the scantling required by the Germanischer Lloyd produced a critical speed at 75 r.p.m. ; in fact, over the whole working range heavy vibration was to be expected. A reduction of scantling was therefore permitted reducing the critical speed to 60 r.p.m. and enabled a steady working range to be obtained. This was verified by corsiograph measurements on the actual trial trip. The vessels are fitted with electric deck auxiliaries throughout. These are said to have worked satisfactorily, although considerable improvement is hoped for as far as simplification and reliability under all conditions are concerned. The oil consumption in port for winches, lighting, &c., amounted to half-a-ton per day. With a coal-burning vessel of the same size a consumption of 7 to 8 tons would be usual. Many other interesting features of these vessels are described and copiously illustrated.—*O. Bleicken and J. Dreves, Werft Reederei Hafen*, November 22, 1922 ; p. 703 ; 8 pp. ; 12 ff.

### The 1922 Meetings of the Schiffbautechnischen Gesellshaft.

Although in matters of age the German Society of Naval Architects must rank as a junior yet the quality of the papers discussed by it year by year are of world wide importance. This year's papers are of exceptional merit and the first that by Geh. Marinebaurat Engel's lecture on "The Fabrication of Ships," is of a sound practical nature. The author states that fabrication was not a product of the late war but already existed in the transition stage of wood and iron shipbuilding. For the internal fittings of passenger vessels it has been adopted since the beginning of the century and in the construction of floating docks, for the last 50 years. It was adopted by most countries during the war and at the end of the war was dropped by most. Germany, however, had proceeded with the idea and a number of the leading bridge-building and shipbuilding firms continue to practise it with success. In the discussion the difficulty of co-operation was emphasised by Dipl. Ing. Achenbach. This difficulty was especially felt in the punching and shaping and consequent erecting of plates but it was suggested that it could be largely eliminated by the adoption of electric welding. Dr. Goldschmidt pointed out with regard to this that Thermit welding would be much more economical and rapid. Professor Laas emphasised the necessity for better organisation which would admit of more unskilled workmen being introduced with a consequent reduction of construction costs. Herr Stieghorst demonstrated that material saving was the most important means of cost reduction and advanced the opinion that far too much riveting was used in shell and decks. The elimination of excess riveting was of greater importance than the use of the multiple punch.

### The Most Economical Ship.

The next paper by Dr. Weitbrecht on "The Most Economical Ship" is of especial interest to naval architects. The author suggests that a comprehensive series of model experiments are very necessary to the complete study of the subject. The author mentions that many similar series exist but owing to their diversity of presentation they are very difficult to utilise. For simplicity Dr. Weitbrecht merely proposes to use the total resistance of the model and bring this up to that of the ship by a method proposed by Bruckhoff in which instead of splitting up the resistance into frictional and wave-making and using their separate laws of comparison the total model resistance is multiplied by the 2·8853900 power of the scale ratio. Dr. Weitbrecht considers that this method is sufficiently accurate for his particular purpose. The model series he proposes is very comprehensive and embraces a main group of $\frac{L}{B}$ ratios 5, 6·5, 8, 9·5 and 11·0. This group contains a subsidiary group with draught-beam ratios of 0·25, 0·35, 0·45 and 0·55 and finally a basis group of block coefficients 0·6, 0·65, 0·7, 0·75, 0·8 and 0·85, making 120 models in all, all derived from one parent set of lines. Only naked models should be tried. The most economical ship is alternatively defined as that which in the same time and over the same distance carries the most deadweight on the same displacement or has the smallest cost per unit carried, or produces the greatest return on a given capital outlay. An example is given deducing the most economical ship for a given size. Dr. Weitbrecht hopes to extend the work by making use of published data. In the discussion Herr Alt referred to similar work carried out by himself some 15 years ago, and showed that Dr. Weitbrecht's work and his own agreed very well. He also pointed out that a vessel's form and proportions will depend upon the type of propelling machinery. Other speakers referred to such points as effect of trim and the possible introduction of mathematically calculated ship forms.

### Oil Burning Arrangements.

The next paper by Paul Muller was on "The Oil Burning Arrangements on some Hamburg-South America Liners." Very complete descriptions of the installations fitted on the *Cap Norte*, *Antonio Delfino*, *Kapsee*, *Ita Cuyaba*, *Vigo* and *Cap Polonio* are given. A brief outline of the general development of the subject is included and very interesting data of actual service conditions and consumptions are published. In comparing oil and coal costs the author points out that many features must be included in the comparison. One especially neglected feature is the respective upkeep costs. This feature is much smaller in oil than in coal-burning vessels. In the discussion Herr Sütterlin made some very interesting observations on the experience and experiments of Blohm & Voss in this connection.

### The Problem of the Propeller.

Probably the most important paper of all was that given by Dr. G. Bauer on "Experiments and Measurements on Ship Propellers." Dr. Bauer has already done considerable work in this connection and his experiments on the *Cairo* will be recalled. In this paper the results of trials on the ferry steamer *Preussen* and the intermediate passenger liners *Antonio Delfino* and the *Sierra Nevada* are examined. As with the *Cairo* use is made of Dr. Schaffran's model propeller experimental work. By the thrust measurements on the actual ships Dr. Bauer is able to bring out very clearly the presence of cavitation and this is of great importance in testing the validity of model experiments. In the cases examined satisfactory agreement with model and ship result was obtained. In the discussion which followed attention was chiefly directed to the validity of the jump from model to full-size results. The next paper was by Professor Pröll on "Propeller Theory." In this paper the "disc" theories of Rankine, Greenhill, and Lorenz, the "blade" theories of Froude, Gümbel, Grammel, Reisner and the latest and more comprehensive theories of Föttinger, Prandtl and Betz are all carefully examined. With the advent of these latter theories the problem of the "open" propeller may be considered as largely solved. However, these are yet largely mathematical and are not quite within the reach of the ordinary constructor. The mathematics of Betz have been simplified by Prandtl and the newer theories will rather be of use in improving an already tried design than for first principle designing. No theory is, however, absolutely complete and practice will, of course, prefer to adhere to model results and application of the principle of similarity.

### Mechanical Determination of Form and Stability.

The next paper was that by Dr. Kempf on "New Instruments for the Mechanical Determination of Ship Form and Transverse Longitudinal Stability." By cutting out in paper the form of the ship's cross sections and by weighing them the value of displacement and transverse and longitudinal form stability can be simply obtained. To obtain a vessel's stability where both heel and trim is present Dr. Kempf recommends a model experiment in conjunction with the use of an instrument termed a stability indicator. This differs from that proposed by Heck, and for use on board ship two further instruments a "Metacentric" balance and a stability pointer are recommended. It is becoming increasingly more important that ships' officers should be conversant with the stability of their craft in all conditions and Dr. Kempf's work is a further step towards this desirable state of affairs.

## ENGAGEMENTS FOR JANUARY.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Meeting in Rankine Hall, 39, Elmbank Crescent, Glasgow, on Tuesday, January 16, at 7.30 p.m. Papers and discussion.

BELFAST ASSOCIATION OF ENGINEERS. Meeting in Municipal College of Technology, on Thursday, January 18, at 7.30 p.m. "A Few Recent Inventions," by R. M. Chambers, M.I.M.E.

INSTITUTE OF METALS. Meeting of London Local Section at the Institute of Marine Engineers, the Minories, Tower Hill, London, E., on Thursday, January 11, at 8 p.m. "Some Aspects of Electro-Deposition," by W. E. Hughes, B.Sc.

INSTITUTE OF MARINE ENGINEERS. Meeting at the Institute, the Minories, Tower Hill, London, E., on Tuesday, January 9, at 6.30 p.m. "Gas Engines and Gas Producer Plants," by Hugh Campbell. Tuesday, January 23, film illustrating Industrial Works: W. Beardmore & Co. Limited. Ladies invited.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Meetings in Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne, on Friday, January 12, and Friday, January 26, at 7.30 p.m. "Review of Different Types of Marine Internal Combustion Engines," by Harold Moore. On Friday, February 2, "Diesel Engine Auxiliaries," by Paul Belzavin (member).

LIVERPOOL ENGINEERING SOCIETY. Meetings at the Royal Institution, Colquitt Street, on Wednesday, January 10, at 8 p.m. "Practical Ship Stability," by A. T. Wall, A.R.C.Sc., M.Inst.N.A. On Wednesday, January 24, "Wave Transmission of Power," by W. Dinwoodie. Thursday, January 25, annual dinner at the Midland Adelphi Hotel, Liverpool.—*Students' Section.* On Thursday, January 18, "The Steam Extraction Engine," by E. Cockshutt, G.I.Mech.E.

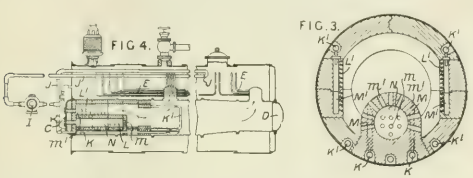
# RECENT PATENTS RELATING TO MARINE ENGINEERING.

Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

**No. 186,350. Furnaces.**

*Smith, W. T., Victoria Street, Bolton, Lancashire. September* 23, 1922, *No.* 25761. *Convention date, September* 26, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 51 (i).]

Steam is used as a fuel in steam-boiler and other furnaces by injecting it into a combustion chamber lined with refractory material and preliminarily heated to a high temperature by oil fuel, which if necessary may be used to maintain the temperature of the combustion chamber. The invention may be applied to all kinds of steam-boilers, in which case the resulting gases may be led into the steam space of the boiler, or to annealing, cupola, blast and other

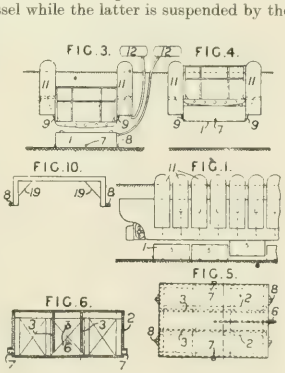



smelting furnaces. Fig. 4 shows the invention applied to a Lancashire boiler and Fig. 3 shows a cross section of the combustion chamber. The front and rear ends C, D of the furnace flue are closed during normal working and the combustion products are led through tubes E into the boiler. Oil fuel for starting up is injected into the main combustion chamber and auxiliary combustion chamber N through openings provided in the front of the furnace. Steam is supplied from the boiler by a pump I through the pipes J, K, $K^1$ to ducts M, $M^1$ delivering into the main and auxiliary combustion chambers through nozzles L, $L^1$. The auxiliary combustion chamber communicates with the main combustion chamber through apertures $m$, $m^1$. In a modified form of the furnace the auxiliary combustion chamber N is dispensed with.

**No. 186,368. Raising Sunken Ships.**

*Reno, J. W., 261, Broadway, New York, U.S.A. April* 27, 1921, *No.* 12107. [*Class* 68 (ii).]

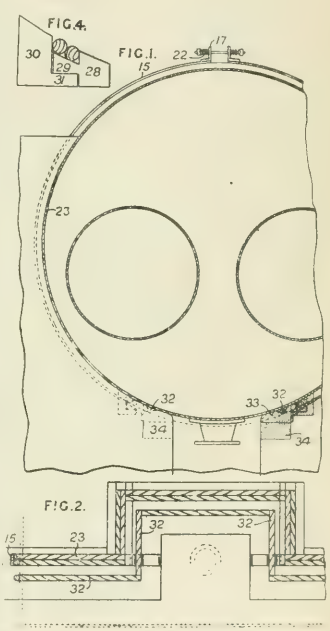
Sunken ships are first raised to a position near the surface of the water by means of a number of buoys 11 attached to the vessel, a number of pontoons or the like 1 are then positioned beneath and against the bottom of the vessel while the latter is suspended by the buoys; the buoys are then detached from the vessel and attached to the pontoon in order to raise the deck above the surface of the water. The pontoons are positioned against the bottom of the vessel by placing them on the sea bottom beneath the vessel or towing the latter over them while it is suspended by the buoys and then filling them with air from a vessel 12 on the surface of the water, water being admitted and discharged through holes 7. The pontoons may be of box shape, Figs. 5 and 6, strengthened by truss frames 2 and transverse walls 3 with their lower edge just clear of the lower side, the arrangement being that when water has been admitted to the pontoon, air may be admitted by the pipe 6 to the centre compartment independently of the other two. On further air being admitted, it passes under the diaphragms 3 to the outer compartments. Rings 8 are provided for reception of the lifting hooks 9, Figs. 3 and 4. The box-shaped pontoons may be used in pairs hinged together or joined by pivoted struts at their upper edges and connected by chains at their lower edges. A modified form of pontoon is shown in Fig. 10 in which the bottom walls are omitted and braces 19 provided. The walls may be hollow and divided into compartments to serve as air chambers.




**No. 186,568. Steam-generators.**

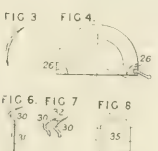
*Lord, J. L., Wellington Cement Works, Bury. April* 15, 1921, *Nos.* 22285/22 and 22286/22. [*Class* 123 (ii).]

Packing 23, Figs. 1 and 2, around the front end of a Cornish or like boiler is pressed against the boiler shell by metal bands 15 fitting in recesses in the setting on each side, the lower ends of the bands being secured in the setting and their upper having brackets 17 which are pressed together by springs 22. The packing is continued around the top walls of the blow-down chamber. The two top inner courses of the brickwork of the chamber walls consists of blocks 28, 30, Fig. 4, so formed with engaging projections 29, 31 and recesses for receiving the packing that the packing may be readily inspected by the removal of outer blocks 30. A further packing 32 may be fitted in recesses around the boiler shell and along the top of the blow-down chamber. Access to the lower end of a packing 23 is obtained by removing a block 33, formed with a recess to receive the packing 32. The block is displaced downwardly after removing a brick 34.




**No. 186,592. Turbines, &c.**

*Metropolitan-Vickers Electrical Company Limited,* 4, *Central Buildings, Westminster. (Assignees of Herr, H. T., Brookway Avenue, Merion, Pennsylvania, U.S.A.) August* 29, 1922, *No.* 23423. *Convention date, September* 30, 1921. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]

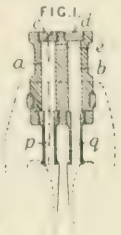



*Blades; radial-flow (bladed) type.*—In turbines of the radial-flow type, the last row of moving blades is adapted to receive the elastic fluid flowing in a general radial direction and to discharge it both laterally and radially. Figs. 3 and 4 show one form in which the blades are semi-circular and concave-convex, being attached to two rings 26 secured by known means to one of the rotors. Fig. 6 shows a modification in which the radial part 31 of the blade is surrounded by a hooked edge 30. A further design is shown in Fig. 8, in which the blade 35 is elongated radially. In all forms of blade the inlet edge is straight and the discharge edge is of greater extent, so as to provide an adequate discharge area with small leaving angles. The construction shown in

Fig. 6 may be modified as shown in Fig. 7 so that the outlet portions 2 of successive blades define a diverging passage for the fluid, with the object of giving a greater range of expansion.

**No. 186,596. Turbines, &c.**

*Soc. Anonima L. Riccio, 19, Via Bandoni, Milan, Italy. September 1, 1922. No. 25790. Convention date, September 26, 1921. Not yet accepted. Abridged as open to inspection under Section 91 of the Act. [Class 110 (iii).]*

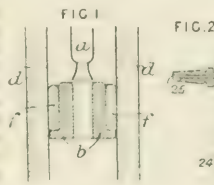


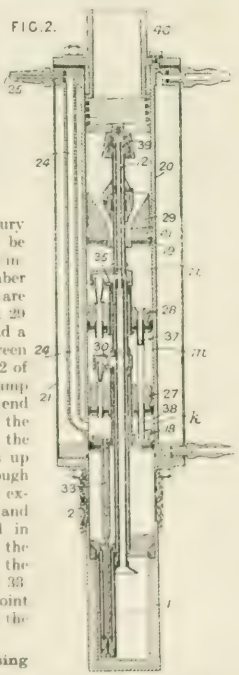

*Cooling ducts.* The blades for internal-combustion turbines are provided with two cooling water ducts *a*, *b* which communicate with each other through a transverse hole *c*, and which are closed at one end by a screw plug *c*, *d* of diameter larger than the maximum dimension of the duct section, and at the other end by tubes *p*, *q* which are expanded in separate holes made in the rim of the wheel on which the blades are mounted. The cooling surfaces of the ducts follow the shape of the convex and concave surfaces of the blades.

**No. 186,609. Ejectors.**

*Gaede, W., 6, Scheerzweiadstrasse, Karlsruhe, Germany. September 20, 1922. No. 25461. Convention date, September 30, 1921. Not yet accepted. Abridged as open to inspection under Section 91 of the Act. [Class 71.]*

In a mercury vapour high-vacuum pump the vapour is discharged from a nozzle *a*, Fig. 1, and is condensed by passing through an annular member *b* surrounded by a water-cooling jacket *d*, a layer of mercury *f* being confined between the jacket and the member *b*. In Fig. 2 the invention is shown applied to a pump for exhausting air from a vessel by way of a passage 46, in which the pump barrel 20 is surrounded by a water jacket 21. A number of vapour condensing chambers *l*, *m*, *n* are provided between the liquid mercury reservoir 1 and the vessel, &c., to be exhausted, the degree of vacuum increasing in each successive chamber from the reservoir. These chambers are fitted with cooling elements 27, 28, 29 constructed as shown in Fig. 1, and a similar element 18 is provided between the chamber *k* and the upper part 2 of the reservoir 1. A low vacuum pump is connected to the nipple 25 at the end of a passage 24 communicating with the chamber *k*, and the mercury in the reservoir is heated. Vapour passes up a jacketed tube 12 and out through nozzles 39, 41, 35, 30. The air is exhausted from the various chambers and the mercury vapour is condensed in the cooling elements 29, 28, 27, the liquid mercury passing back into the reservoir 1 through passages 37, 38, 33. Leather cups 19 ensure a tight joint between the cooling elements and the water jacket.

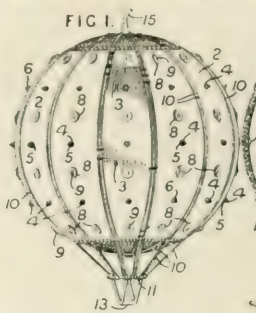


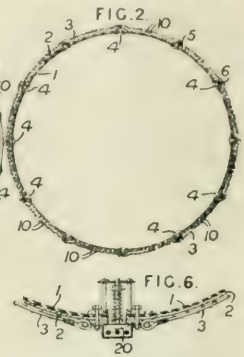




**No. 186,972. Pontoons for Raising Sunken Ships, &c.**

*Savage, A. E., 542, West Twenty-third Street, New York, U.S.A. June 13, 1921. No. 16199. [Class 68 (ii).]*

A collapsible pontoon for raising sunken ships or other objects comprises a number of concentric casings, all connected up by attachment means, each of which extends only from one casing to an adjacent casing, at a number of equally spaced points. The inner casing 1, Fig. 2, is of rubber or other airtight material, the intermediate casing 2, Figs. 1 and 2, is of strong non-elastic material such as cotton duck, and the outer casing 3 consists of a rope network. The inner casings 1, 2 are secured together by bolts 4 with washers 5 and nuts 6, and the outer casing 3 is secured to the casing 2 by means of patches 8 with straps 9 sewn on to the casing 2. The outer casing 3 is preferably formed of segments with circular pole sections, and to it are secured stay-ropes 10, which are secured to a steel ring 11 carrying a cross bar 13 for attachment to the ship.





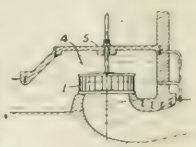


&c. An air-tube 15 is provided, and an adjustable-spring loaded safety-valve 20, Fig. 6, is located at the base of the pontoon.

**No. 187,032. Turbines.**

*Armfield & Co. Limited, J. J., Avon Ironworks, Ringwood, Hampshire. (Honold, R.: Waltendorf, near Graz, Rudolfstrabe, Austria.) July 15, 1921. No. 19102. [Class 110 (iii).]*

A water turbine of known type such as the "Francis" turbine having the rotor 1 partly below the headwater line is provided with an entrance chamber 4 in which the upper boundary surface 5 is above the headwater line. The water enters the chamber 4 at a lower level than headwater line, and is caused to rise and fill the chamber either by the formation of vortices in the water or by some known form of ejector or pump operated either by external power or directly by the flow of water from the head to the tail-water levels. In modification the upper boundary of the entrance chamber is at or below the headwater line, but the water therein is at a pressure less than atmospheric by the velocity of the water passing to the turbine or by some known form of ejector or pump.




**No. 187,044. Steam Generators; Heating Water.**

*Hope, J. A., 36, Victoria Street, Westminster. July 22, 1921, No. 19761. [Classes 64 (i) and 123 (ii).]*

Relates to a boiler for heating water or raising steam of the kind comprising superposed sections enclosing horizontal flues. Sections $A^2$, $A^3$, $A^4$ fitted above a fire-box section $A^1$ are so shaped as to enclose flues directing the furnace gases forwards and backwards between the sections. Dampers between the sections and the smoke-box N may cut off the outlet from the flues and allow the gases to pass directly into the smoke-box. The sections are connected together by external pipes B. Cold water enters at the top section and hot water or steam is taken off from the section immediately over the fire-box. Sediment is removed through doors M. Doors are provided at the front of the boiler to give access to the flues.

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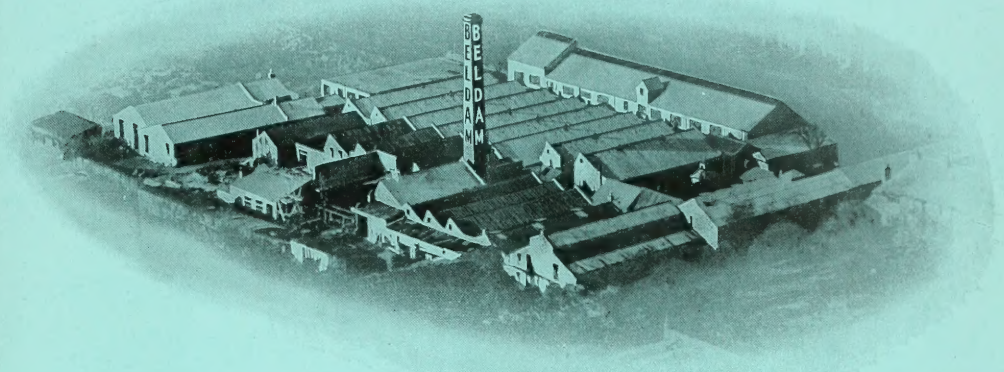


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